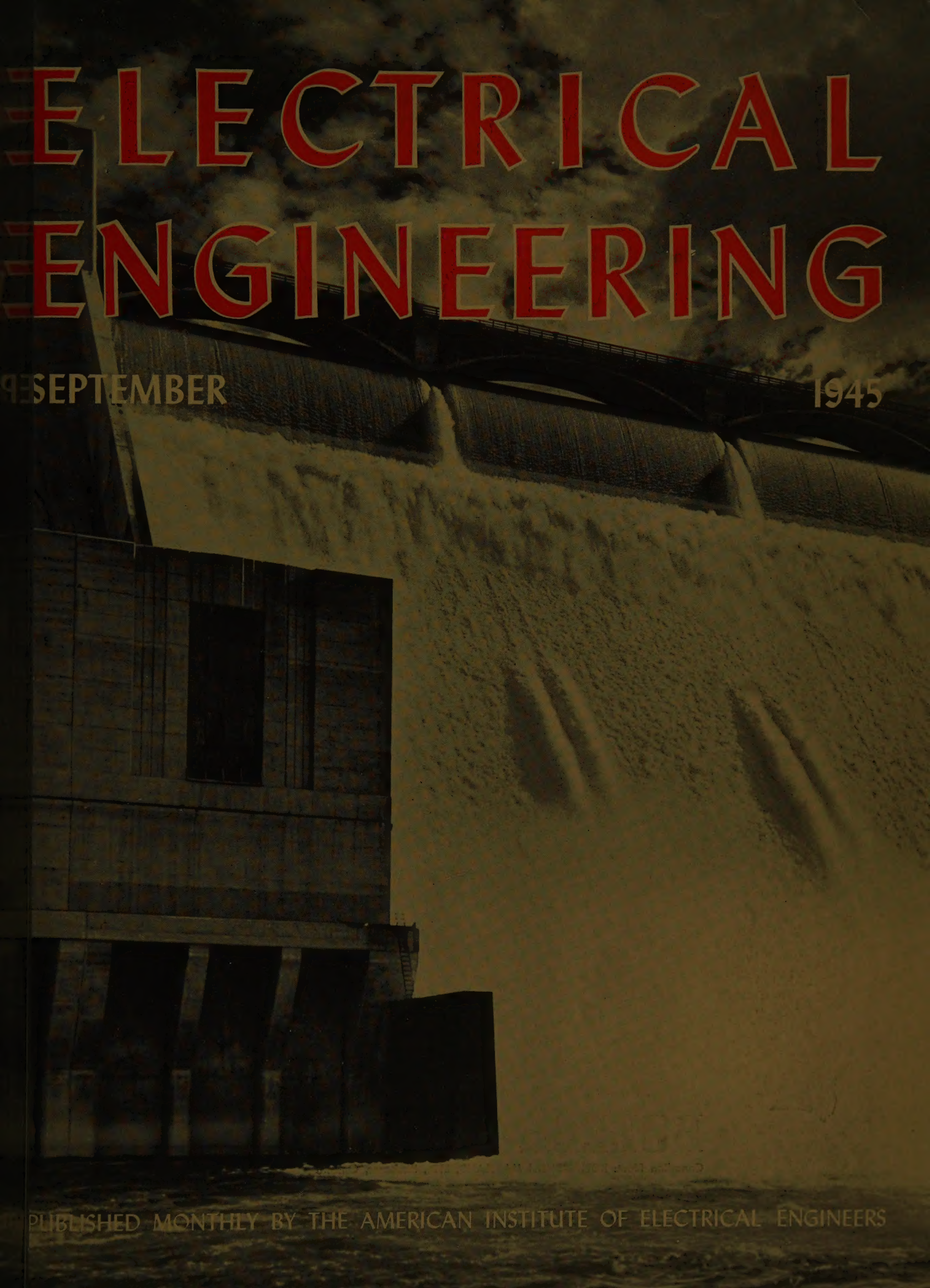
# ELECTRICAL ENGINEERING

SEPTEMBER 1945



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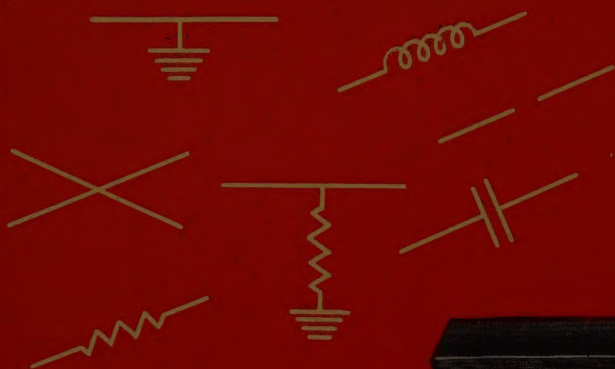

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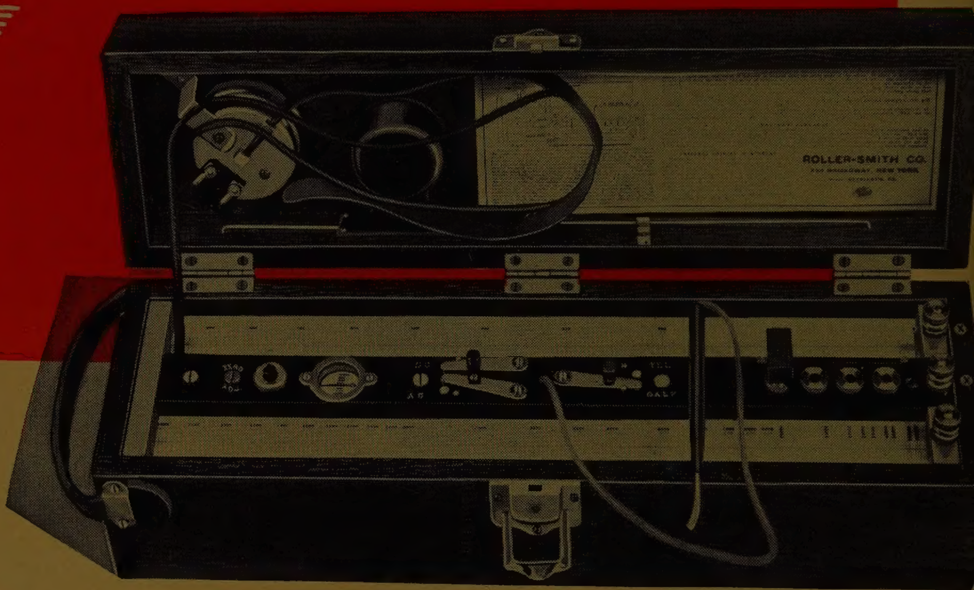


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## TRANSACTIONS SECTION

*(Follows EE page 350; a preprint of pages 607–70 of the 1945 volume. Any discussion of these papers will appear in the December 1945 "Supplement to Electrical Engineering—Transactions Section" and in the 1945 volume.)*





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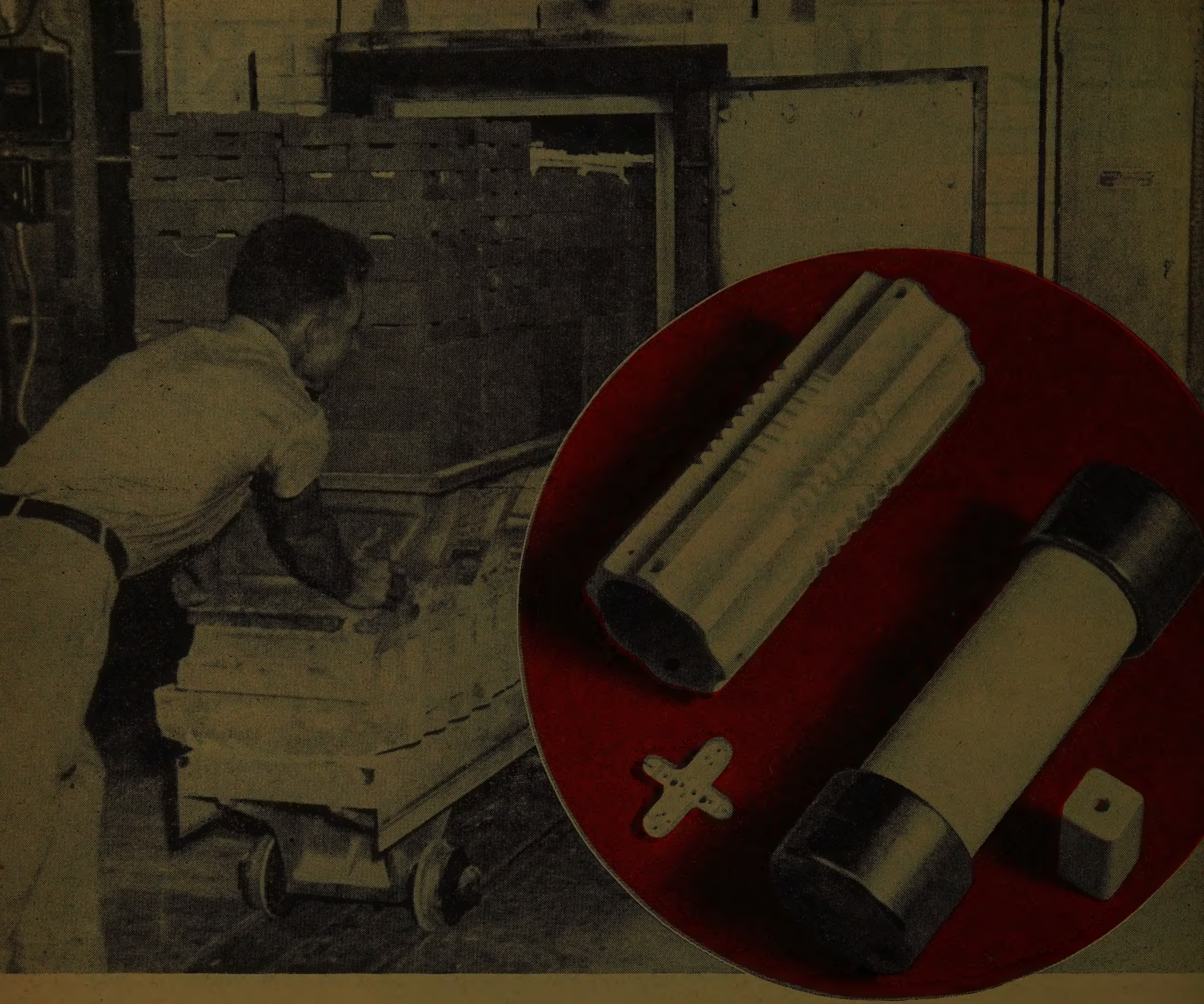

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ELECTRICAL ENGINEERING

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# Beginnings of Nuclear Physics

K. K. DARROW

**Comparison of the field of nuclear physics and electronics; an analysis of the charges and masses of the nuclei in line with the nuclear theory; definition and description of the process of transmutation and its reactions and creations, namely, radioactive substances and stable nuclei, are the main points discussed in this article.**

As I UNDERSTAND the terms of my invitation, I am to introduce to you a topic which cannot claim to be a part of electronics, unless on the Tennysonian principle—"I am a part of all that I have met." Nuclear physics has indeed met with electronics, to its considerable gain; for some of its most essential measuring devices and auxiliary gadgets belong to the field of this conference. There is even a more intimate relationship, for nuclear physics has the privilege of watching over the birth and the death of electrons; yet out of all the myriads of electrons which you administer, I suspect there are only a few of which it has been the godfather and I hope there are only a few of which it will see the extinction. By and large, nuclear physics pertains to the massive, the heavy, the inert and the comatose parts of matter, while electronics pertains to the lightweight, the sprightly and the nimble parts. You will learn, however, that given the right circumstances and the proper assistance, the inert parts of matter can become exceedingly sprightly, and exchange their state of coma for a quite remarkable liveliness.

What are these parts of matter, to which I have been condescendingly referring as "inert" and "comatose"? Well, you all know that according to modern views, every atom of matter consists of a nucleus with a positive charge, and a swarm of negative electrons which are constrained by that positive charge to stay around the nucleus. The electrons are your servants, and the nuclear physicist does not try to tempt them away from their allegiance to you. They do him the good office of indicating the size of the positive charge on the nucleus; for this is equal to the sum of the charges on the electrons, and it is easier to count the electrons than to measure the nuclear charge directly. Thanks to the electrons, we know the charges on the nuclei of all of the chemical elements. If you look at a modern table of the elements, and not at one of those grimy old wall maps that used to hang in chemistry lecture rooms before World War I, you will see these charges indicated by a prominent number next to the symbol of every element. This number is 1 for hydrogen, 2 for helium, 3 for lithium, 4 for boron, and so on up to 92 for uranium, the last and heaviest element of the periodic table. It is the charge on the nucleus expressed as a multiple of the electron-charge $e$, and we call it the "atomic number."

These atomic numbers are not, however, the only numbers which are juxtaposed to the symbols of the chemical elements, in a modern or even in an ancient table. In fact if you go back to the old tables of the pre-World-War era—and I regret that even now it is not so difficult as it should be to find one still doing its superannuated duty on a wall—you go back to an era when atomic numbers were unknown, and yet you find a number affixed to every element. This, of course, was the "atomic weight." Now I have introduced the second feature of the nucleus: its weight, or mass. My reason for disparaging the nucleus as being heavy and inert was simply, that it has nearly the entire mass of the atom. In fact, there is no atom for which the masses of all the negative electrons put together amount to as much as one one-thousandth of the mass of the nucleus. That is why I said at the beginning of this talk that electronics has the lightweight, the sprightly and the nimble parts of matter to play with. Or to use another analogy, you get the froth and nuclear physics gets the potent part.

You may now expect me to say, or indeed you may feel that I have said already, that the ancient tables give the masses of the nuclei, at least to within one tenth of one per cent, under the old-fashioned name "atomic weight." This would indeed be true, apart from minor errors in measurement, but for one important fact. Each element, with only a few exceptions, is a mixture of atoms of several different kinds with different masses. We call them "isotopes." If an element has only one isotope, like fluorine or beryllium for instance, then the chemical atomic weight does give very nearly the mass of the nucleus. But in the much commoner case of an element with two or several isotopes, the chemical atomic weight is just a sort of weighted mean of the masses of two or several different kinds of atom.

Such a weighted mean is of almost no interest to the nuclear physicist, but fortunately he has methods—the earliest goes back about 32 years—for measuring the masses of the individual isotopes. A really modern table of the elements will display, next to the symbol of each element, not only its chemical atomic weight which is still of value to the chemist, but also the weights of its individual isotopes which are of great concern to the nuclear physicist. This of course begins to make such a table a pretty rich and copious affair.

The time has come for pinning down these generalities with some examples. I repeat that we are now concerned with the charges and the masses of the nuclei, and I soon will make clear how greatly they merit our concern. My examples will be taken from the simplest nuclei, which are those of the lightest elements, the elements at the commencement of the periodic table.

Hydrogen is the first of the elements. Its nuclear charge is fixed by the very well-known fact that the hydrogen atom has only one electron. This charge is therefore equal to the charge of the electron, and is positive in sign. In other words, the nuclear charge of hydrogen, when expressed in terms of the electron-charge $e$ as unit of charge, is $+1$. In still other words, the atomic number of hydrogen is 1. We put this down as the first item of information about hydrogen nuclei.

Now for the nuclear mass: the old tables say that the atomic weight of hydrogen is 1.008, but this is just a weighted mean of the masses of the two isotopes

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Essential substance of an address delivered at the National Electronics Conference, Chicago, Ill., October 5–7, 1944, and published in *Proceedings* of the National Electronics Conference, volume 1, 1944.

K. K. Darrow is research engineer with the Bell Telephone Laboratories, Inc., New York, N. Y.

called "light hydrogen" and "heavy hydrogen," respectively. The actual atomic masses by recent measurements are found to be 1.0081 and 2.0147. I give these values to five significant figures, all of which are believed to be sure; I deduct 0.0005 for the mass of the electron which is part of every complete hydrogen atom, and write 1.0076 and 2.0142 for the masses of the two kinds of hydrogen nuclei. Now an omission must be rectified. I have told you that the values of nuclear charge are given in terms of $e$ as unit of charge, but I have not yet told you the unit of mass in terms of which these nuclear masses are expressed. This unit of mass is one sixteenth of the mass of the commonest kind of oxygen atom. Both units are very small, compared with those of ordinary usage: the electrical one about $10^{-19}$ of a coulomb, and the other about $10^{-23}$ of a gram. The reason for this extravagant smallness of the units is that the nuclear physicist talks about individual atoms and individual nuclei, while the chemist talks about gram-molecules of atoms and the electrical engineer talks about legions of electrons. It is in fact one of the characteristics of the nuclear physicist, that often he observes and even measures an event in the life of a single nucleus.

Next, it will be convenient and indeed essential to adopt some names or symbols for these nuclei. As it happens, the two which I have just introduced to you have names: "proton" and "deuteron" for the nuclei of light and heavy hydrogen, respectively. But there are about 600 different nuclei, and if they all had names our memories could hardly stand the strain. To make a symbol for a nucleus, we begin by putting down the chemical element to which it belongs—H for hydrogen, in this instance. Then at the lower left we put the atomic number, 1 in this instance, so that the symbol becomes ${}_{1}\mathrm{H}$. Now we have introduced a superfluous bit of luxury, since the chemical element determines the atomic number and vice versa; but it often is regarded as good practice to hammer an idea in by repetition, and that is what we do when we give both the atomic number and the chemical symbol. Lastly we put, at the upper right, the nuclear mass—but not to all the five or six significant figures which the measurements permit. We need not be perpetually reminded of the exact masses: we shave off all the figures to the right of the decimal point, and write ${}_{1}\mathrm{H}^{1}$ and ${}_{1}\mathrm{H}^{2}$ for proton and deuteron, respectively.

With the aid of this notation, I now introduce you to four more nuclei. The second of the elements is helium. Its nuclear charge is $+2e$, its atomic number is 2, and it has two isotopes of which the nuclear masses are 3.0161 and 4.0029, respectively. The symbols for these two nuclei are ${}_{2}\mathrm{He}^{3}$ and ${}_{2}\mathrm{He}^{4}$, respectively. The latter is one of the few which have names of their own: it is called "the alpha particle." The third of the elements is lithium, having two isotopes of which the symbols are ${}_{3}\mathrm{Li}^{6}$ and ${}_{3}\mathrm{Li}^{7}$. The nuclear masses of these two are given as 6.0154 and 7.0177.

### THE NUCLEAR THEORY

The next step is, to introduce a model for these nuclei. As we take this step, theory rears its head. Nuclear theory has a bad reputation, which some portions of it deserve; but it commences with a very simple and effective postulate, and you have no cause for alarm over what happens to the nuclear theorist in his further explorations, for I shall not be leading you so far.

Going back to the proton for our start, we are to accept it as an elementary particle. I represent it by a circle with a cross inside to indicate the positive charge: $\oplus$. You may visualize it as a sphere.

Going on to the deuteron, our program is to represent it in the simplest conceivable way. This way consists in imagining the deuteron as a pair of particles stuck together, one being the proton, while the other perforce must have about the same mass as the proton but no charge at all. Let us postulate such a particle, give it the name of "neutron" by allusion to its lack of charge, and represent it by a circle without a cross inside, $\bigcirc$. Now the model of the deuteron is this: $\oplus\bigcirc$.

The grand simplicity of nuclear theory is, that we are permitted to go all the rest of the way and to model other nuclei however massive, with no more building-blocks than just these two, the proton and the neutron. Thus, the other four nuclei which I have individually mentioned are to be depicted thus: $\oplus\oplus\bigcirc$ for ${}_{2}\mathrm{He}^{3}$, $\oplus\oplus\bigcirc\bigcirc$ for ${}_{2}\mathrm{He}^{4}$, $\oplus\oplus\oplus\bigcirc\bigcirc\bigcirc$ for ${}_{3}\mathrm{Li}^{6}$ and $\oplus\oplus\oplus\bigcirc\bigcirc\bigcirc\bigcirc$ for ${}_{3}\mathrm{Li}^{7}$. Notice that such a symbol as ${}_{3}\mathrm{Li}^{6}$ carries on its face the prescription for making the appropriate model. The figure on the lower left is the number of protons, and the figure on the upper right is the number of particles altogether, the sum of the protons and the neutrons. One would probably not enjoy the task of drawing a cluster of 226 circles and putting crosses into 88 of them, but the symbol ${}_{88}\mathrm{Ra}^{226}$ (for the nucleus of radium) relieves us of that. It tells us how many circles and crosses we ought to put down if we were doing it, and the rest we can leave to the imagination. I mention here that we are to call the total number of circles or of particles, protons and neutrons together, by the name of "mass-number."

My next duty is to introduce to you the neutron, no longer as a merely hypothetical particle but as a real one. The word "real" is a rather dangerous one for a physicist to use, and I hope that there is no professional philosopher in the room who would be nasty enough to insist that I justify my use of it. All that I want to imply is, that nuclear physicists are very well acquainted with the "free" neutron, not attached to a proton or to anything else [illegible] around by itself in emp[illegible] though not so secu[illegible]le of gaseous air. Of both [illegible]ding-blocks, neutron as well as p[illegible] it can be said [illegible] are independently known. I [illegible] have avoided saying that we make nuclear models by adding hypothetical neutrons to actual protons; the two are on the same footing, and actually the nuclear models that I have been sketching for you were not believed in, until the two were both established on the footing of experiment.

So, let us now add the neutron to our list of nuclei, at the beginning where it belongs. Its symbol must tell that its charge is zero; also, that its mass number is 1, for as I have lately told you it has about the same mass as the proton. The symbol is accordingly ${}_{0}\mathrm{n}^{1}$. What is the accurate mass, as distinguished from that approximation which we call the "mass-number"? I go to the most recent tables, and I find 1.0089.

Now surely we have all the material necessary for predicting the masses of all nuclei. I add the 1.0076 of the proton and the 1.0089 of the neutron, and I get 2.0165, which must be the mass of the deuteron. I double this figure to get the mass of a cluster of two neutrons and two protons, and arrive at 4.0330, which must be the mass of the alpha particle. The figures seem irreproachable, and yet they have lied. The masses of the deuteron and the alpha particle are 2.0142 and 4.0029. Have these values been badly determined? Not so! They are very well known. Could it be that the mass of the free neutron has been badly determined, or that the free neutron of experience is after all a different particle from the hypothetical neutron of nuclear structure, so that for the mass of the latter we should have chosen a different value? We cannot get anywhere along this route, for if this were the whole trouble the mass of the alpha particle would have to be twice that of the deuteron, 4.0284 instead of 4.0029. Apparently there is something very wrong. But actually there is something very right; and now we have reached the most important single point of this discourse.

The point may be paraphrased as follows. If one assumes that a body is made up of particles, one is perforce assuming that the particles stick together. "Stick together" is of course a layman's term; a physicist will say that energy must be supplied to tear the particles apart. But as Einstein told us long ago, energy is always weighted down with mass, and accordingly the mass of the system of particles must increase when they are torn apart. Reverse the process (in thought). When the particles come together and stick and form the body, its mass must be smaller than the aggregate of the masses which they had while they were free. Thus when we figure out the sum of the masses of all the protons and all the neu-

trons that go into a nucleus and find it greater than the mass [illegible]—as we always do fin[illegible] dis-aster, but a wel[illegible] In-stead of contradic[illegible] [illegible]eory, it is [illegible]t the theory ne[illegible]

Th[illegible] discrepancy, or deficiency of mass is called "the binding-energy of the nucleus." This is a defective name, which ought to be improved. The quantity in question, the deficiency of mass of the whole compared with its parts, ought to be called the "binding want-of-energy of the nucleus." You notice that now I am using "mass" and "energy" as though they were synonymous. This is one of the habits of nuclear physicists, and on the whole it is a sound one. As a consequence, nuclear physicists get into the habit of using the units of mass and energy indifferently, with reference to the very same thing. For instance you will hear them say that the mass of the proton or the neutron is around a billion of electron-volts, or that the mass of the electron is around half-a-million. The unit of mass which I have been using amounts, on the energy scale, to 931,000,000 electron-volts. The binding want of energy of the deuteron, 2.0165 less 2.0142, is accordingly about 2,200,000 electron volts and that of the alpha particle, 4.0330 less 4.0029, has the considerably greater value of some 28,000,000 electron volts. We note that in the alpha particle, the constituents lose on the average three quarters of one per cent of their mass; this is about as great a proportionate binding want-of-energy as is ever observed.

Bear with me for one more step which I promise you shall take us on to transmutation, the topic above all others which I suppose has drawn you hither.

Consider two protons and two neutrons. First, let them be united into a pair of deuterons: ⊕○, ⊕○. This assemblage has a total mass of 4.0284. Now suppose they are regrouped into a cluster of two protons and one neutron, plus a free neutron somewhere else: ⊕⊕○, ○. This assemblage has a total mass of 3.0161 plus 1.0089, or 4.0250. Call them the "first grouping" and the "second grouping," respectively. The second grouping compared with the first has a mass (or energy) smaller by 0.0034 of a mass-unit (or 3,170,000 electron volts). Nuclear physicists in their exchangeable currency of mass and energy have the habit of describing the big coins in mass-units and the small change in energy-units, so they would commonly say that the mass of the second grouping is less than that of the first by 3,170,000 electron volts.

You see, of course, that the four particles can never go from the second grouping to the first unless energy is administered to them from the outer world. They can shift over from the first grouping to the second without any such contribution, and moreover they have a tendency to do so. Here is the basic principle of transmutation: protons and neutrons have a tendency to go from one to another grouping, if when they do so there is release of energy. Some of you will be reminded of an ancient principle of chemistry, to the effect that a chemical reaction tends to take place provided it involves the release of energy. Actually this is not quite the statement now accepted in chemistry, in which science it has been found necessary to substitute the concept of "free energy" for that of plain energy; but in nuclear physics we still content ourselves with the older form of the principle. The tendency, then, exists; but apparently it is not usually sufficient—some obstacle has to be overcome, some opportunity provided. How then shall we give opportunity for the component particles of a pair of deuterons to follow their tendency, and regroup themselves with release of energy into the second grouping?

The essential is obviously, that the deuterons shall be brought close together—or let me say for vividness, they must be brought into contact with each other. To this however there is an obstacle, arising from the positive charges on the deuterons. Both being of the same sign, they repel one another in the normal manner of electrostatics; and if two deuterons were to aproach one another with the ordinary speed of thermal agitation, they would turn back in their tracks and recede from one another without ever getting even nearly into contact. To get them into contact, the nuclear physicist must drive one of them against the other—or if you prefer, he must project, precipitate, throw, or hurl one of them against the other; or rather, since he cannot work with just two and wouldn't want to anyhow, he must bombard a flock of stationary deuterons with a stream of high-speed deuterons, hoping that a perceptible fraction of the impacts will lead to contact and to the spontaneous regrouping.

As you already know, or have divined, the hope is justified if the bombarding deuterons are driven hard enough; and this is the purpose of the high-voltage engines, the cyclotrons and the electrostatic generators and the transformer-rectifier sets, which dominate the laboratories of the so-called "atom-smashers." I cannot give you a precise figure for the minimum voltage which is required for bringing the deuterons into contact, for there is no sharp minimum voltage. If the voltage is 1,000,000, and the energy of the bombarding deuterons accordingly 1,000,000 electron volts (this is the definition of 1,000,000 electron-volts!) the "yield" of this process of regrouping is quite ample for easy observation. The energy of the impinging deuteron adds itself onto the 3,170,000 electron volts released by the regrouping, and the sum total turns up as kinetic energy of the cluster of particles ⊕⊕○ and the isolated neutron ○.

I have been depicting this process by models—now let it be represented in symbols. The cluster ⊕⊕○ is evidently the nucleus ${}_2He^3$ which has already been mentioned. The isolated neutron has the symbol ${}_0n^1$, and the process is written thus:

$${}_1H^2+{}_1H^2={}_2He^3+{}_0n^1+3.17\text{ MEV}$$

Two nuclei of hydrogen have disappeared; one nucleus of helium and one free neutron have appeared in their place, and 3,170,000 electron volts, which previously existed as part of the mass of the deuterons, has been transformed into kinetic energy of the helium nucleus and of the neutron. This is a "reaction of transmutation," and the descriptive equation is an equation of "nuclear chemistry," similar in aspect to the equations of ordinary chemistry but of a kind which would horrify any chemist of the pre-World-War era, could he but come back and look upon it.

On this example I can base a sort of combined definition and description of the process of transmutation—Transmutation occurs when two nuclei are brought into contact with one another, and is a process in which the original protons and neutrons regroup themselves into two newborn nuclei with a release of energy.

Not every case of transmutation conforms to this description although great numbers of them do. There are also cases in which the impinging nucleus unites itself with the nucleus which it strikes, the energy which is released being carried off by a corpuscle of light. There are also cases in which the impinging body is itself a corpuscle of light; thus, the deuteron itself may be divided into a free proton and a free neutron, by administering to it a corpuscle of light which has energy enough to fill up that deficit of mass or binding want-of-energy of 2,170,000 electron volts which so-to-speak has been holding the deuteron together. There also are cases in which two neutrons and two protons, bound together into an alpha particle, release themselves spontaneously from a much more massive nucleus, because the mass of that original nucleus is greater than the sum of the masses of the liberated alpha particle and of the residual nucleus which the alpha particle leaves behind. This last case is exemplified by radium, and what I have just given you is the description of the radioactivity of radium. There are still other cases.

When a pair of deuterons is driven into contact, something different may happen from what I have just been describing. You may expect me to say that sometimes the deuterons unite themselves into a single alpha particle. This would indeed entail a wonderful release of energy, but apparently it does not happen. There is something or other to prevent it, and also there are inhibitions on various other conceivable reactions of transmutation which also would entail a release of energy; we can only hope that nuclear theory will be able to explain them. The alternative

thing which sometimes does happen, when deuteron meets deuteron, is represented thus by model:

$$\oplus\bigcirc \text{ and } \oplus\bigcirc \text{ into } \oplus\bigcirc\bigcirc \text{ and } \oplus \qquad (1)$$

The four particles regroup themselves into a cluster of one proton and two neutrons, and a free proton off by itself. Evidently then this grouping has a smaller mass and energy than the first grouping into a pair of deuterons. Writing the process as an equation of nuclear chemistry, we have:

$$_1H^2 + {}_1H^2 = {}_1H^3 + {}_1H^1 + Q \qquad (2)$$

in which $Q$ stands for the release of energy.

This process leads to a free proton, and also to a nucleus of an isotope of hydrogen which has not yet been mentioned in this discourse. I left it out deliberately, because it has a feature which sets it apart from the six atom-nuclei which I did mention. It is unstable and it is radio-active—two words which are almost, though not quite, synonymous in nuclear physics. The manner of its radioactivity is this. After a lapse of time which may be months or may be years or may be very short, such a nucleus emits a negative electron. Incidentally it thus becomes a contributor to electronics, and you should be grateful for its contribution, though if all the electrons contributed by $_1H^3$ nuclei in the history of the world were gathered together I do not think they would supply a pentode very long.

Where does this nice fresh electron come from? Following the theorists of today, I have told you that there are no electrons in a nucleus, nothing but protons and neutrons in fact. There was indeed a time—it extended up to 1932—when the theorists did assert that there are electrons in the nucleus. I will not swear that no such time will ever come again, for the flexibility of theorists is something wonderful. However, at present we regard the nucleus as consisting of protons and neutrons exclusively, and this policy has so many advantages that we gladly accept its corollary, which is, that the electron comes into being at the moment when it starts out from the nucleus. If this seems absurd to you, I remind you that it is the assumption you all make in regard to light. Atoms emit light, and yet you do not suppose that there are corpuscles of light running around inside atoms all the time. You suppose that the atom releases energy and that this energy takes the form of light as soon as it escapes; and you are expected to make the same supposition about the nucleus emitting the electron. I hope you are satisfied with this doctrine, because for the present at least it is the doctrine which you have to take.

Let us now envisage the condition in which the departure of the electron leaves the former $_1H^3$ nucleus. The electron took off a charge $-e$ from a nucleus which already possessed a charge $+e$, and which accordingly now possesses a charge $+2e$. The newborn nucleus is therefore an isotope of helium. The electron also took along its mass, which however is only 0.0005 of a mass-unit, and the mass of its kinetic energy which also is small. The mass-number of the newborn nucleus is therefore the same as that of $_1H^3$, and its symbol must be $_2He^3$. The equation is:

$$_1H^3 = {}_2He^3 + (\text{neg. el.}) + E \qquad (3)$$

in which $E$ stands for the kinetic energy of the negative electron (plus the recoil energy of the newborn nucleus, which is slight). The model is:

$$\oplus\bigcirc\bigcirc \text{ into } \oplus\oplus\bigcirc \text{ and (neg. el.)} \qquad (4)$$

so that in effect we assume that when the negative electron departs, one neutron turns into a proton.

Is the $_2He^3$ nucleus at which we have arrived just the same as the $_2He^3$ nucleus of which I earlier spoke, the one which is derived directly from an alternative reaction between deuterons? Let me indicate how this question might be answered. By measuring the kinetic energies of the $_1H^1$ and $_1H^3$ nuclei resulting from the process 2, we can evaluate $Q$ of equation 2, and then solve the equation for the mass of $_1H^3$ in terms of the masses of $_1H^1$ and $_1H^2$, which last are very well known. By measuring the kinetic energy of the emerging electron we can evaluate $E$ of equation 3 and then solve this equation for the mass of $_2He^3$. By going back to process 1 and measuring the kinetic energies of the $_2He^3$ and $_0n^1$ we can evaluate the $Q$ of that equation, which I have already given as 3,170,000 electron volts. We can then use equation 1 to determine the mass of the $_2He^3$ nucleus derived directly from this reaction, provided we have a good independent value of the mass of the neutron. Actually it is more nearly the other way about: we use this equation more for determining the neutron-mass, and we get the preferred value of the mass of $_2He^3$ from the equation describing some other reaction of transmutation in which the masses of the two original nuclei and of the other newborn nucleus are particularly well known. There are in fact so many reactions of transmutation that for many a nucleus the mass can be determined in a half-dozen different ways, and as a rule the concordance is remarkable.

### SUMMARY

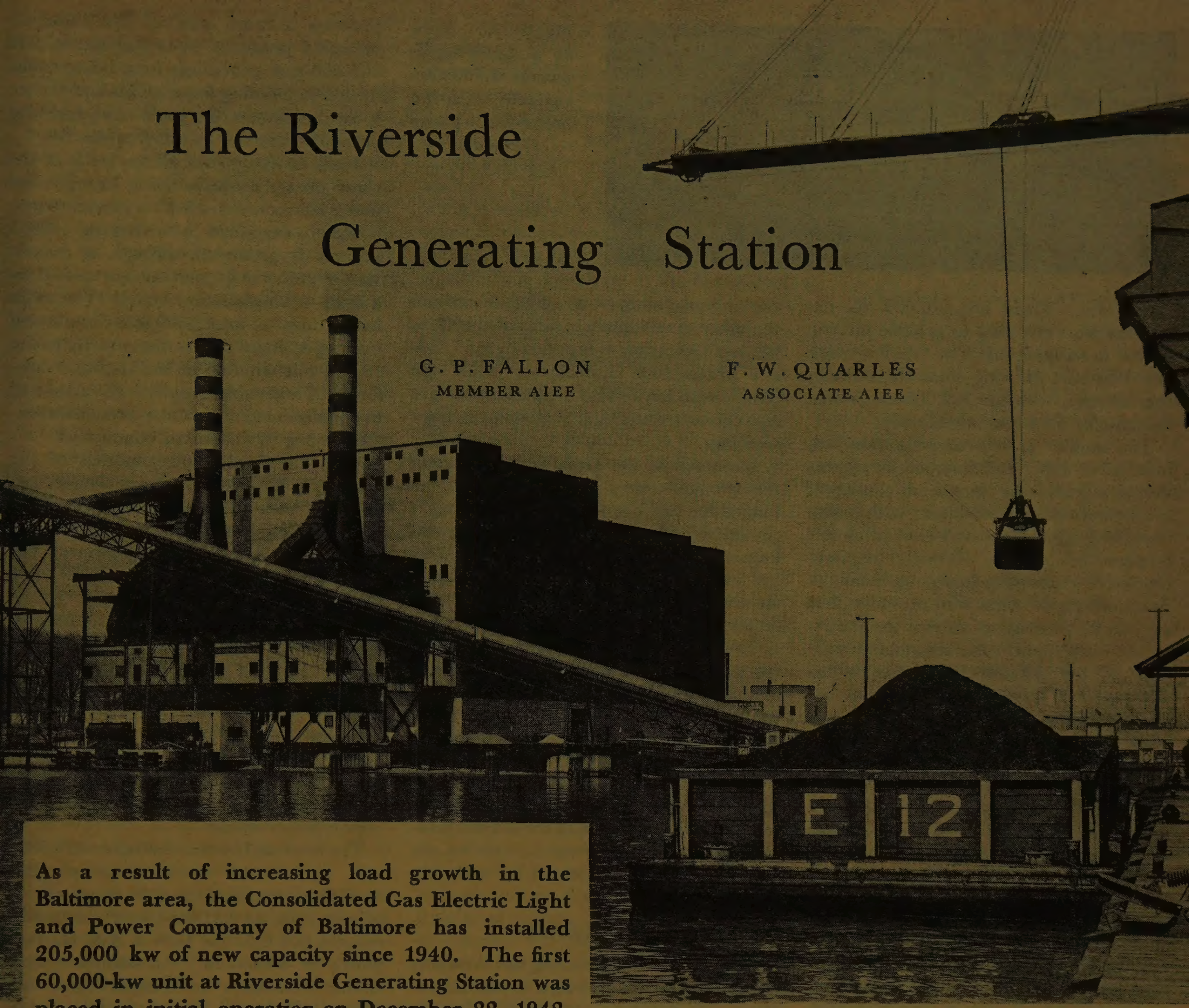
Now let me summarize. The atom-nucleus is a body comprising nearly the entire mass of the atom. It is distinguished by the features of mass and positive charge, as well as others which in the time available there was no point in mentioning. The positive charge determines the element to which it belongs, the mass determines the isotope. A nucleus is regarded as a cluster of particles of two kinds, the proton which has a charge and the neutron which does not. In making a model for a given nucleus, the number of protons is adjusted to fit the charge, the number of neutrons is adjusted so that when added to the number of protons it gives approximately the right mass. The proton and the neutron are well known as free and independent particles in Nature, and their masses have been measured. The mass of any nucleus, the free proton and neutron alone excepted, is slightly but significantly less than the sum of the masses of the protons and neutrons which make it up. The deficit is the binding want-of-energy of the nucleus, the measure of the tightness with which it is held together. The actual mass is a measure of the energy of the system of protons and neutrons grouped into this nucleus. If two nuclei are driven into contact, and if there is an alternative grouping of their component particles which is of lesser energy than the actual one, then there is a tendency for the particles to go over into the alternative grouping. When this tendency is fulfilled, two newborn nuclei (or sometimes only one) appear in place of the two which originally collided, but they contain just the same basic particles in a new distribution. This is transmutation. Sometimes one of the newborn nuclei has a tendency to emit an electron spontaneously. This is a type of radioactivity, and we call such nuclei by the name of artificial or induced radioactive substances.

Such are the beginnings of nuclear physics. Just how small a beginning I have made, I will close by indicating. One hint I have already given: there are a great many reactions of transmutation, of which I have described no more than two. You have been told of one artificial radioactive substance: actually there are more than 300, and among them is included at least one isotope of every element known. In addition, a great many stable nuclei have been created by transmutation. I am not aware that anyone has lately made an effort to count them all; but it is known that there are nearly 300 kinds of stable nuclei found on this earth, and it is my guess that more than half of them have been reproduced by transmutation. Have any stable nuclei been made which were not previously known? Yes, $_2He^3$ was such a nucleus, and so also was an isotope of oxygen, $_8O^{17}$; but both have since been discovered, very rare but unmistakable. It appears therefore that Nature has done very well in stocking this earth with all possible types of stable nucleus. Perhaps men do not have the privilege of building nuclei which are both unprecedented and immortal; but for mortal beings this may be seemly. Things which are transient are often regarded as more precious than things which are permanent. The nuclear physicist has made enough of a diversity of these transient radioactive nuclei, to give him ample right to style himself a nuclear architect. How precious they may be is something that you will never fully hear, unless you ask the chemists, the biologists, and the physicians to join the physicists in telling you the story.

# The Riverside Generating Station


G. P. FALLON
MEMBER AIEE

F. W. QUARLES
ASSOCIATE AIEE



**As a result of increasing load growth in the Baltimore area, the Consolidated Gas Electric Light and Power Company of Baltimore has installed 205,000 kw of new capacity since 1940. The first 60,000-kw unit at Riverside Generating Station was placed in initial operation on December 22, 1942, and the second, on April 26, 1944. The two-unit installation is the initial step in the development of a waterfront site convenient to both the transmission facilities and the growing industries.**


GROWTH of industrial load in the eastern section of Baltimore and on the north side of the Patapsco River resulted in 1937 in the extension of transmission circuits from Westport and Safe Harbor generating plants to the Riverside property, a tract of land situated on the Patapsco River, southeast of the Municipal Airport, and acquired by the Consolidated Gas Electric Light and Power Company of Baltimore in 1922.

There were in existence at that time two 33,000-volt underground circuits from Westport through Gould Street and Newgate Substations to Riverside. The Safe Harbor circuit took the form of a 220,000-volt transmission line terminating in a 126,000-kva transformer bank stepping down to 33,000 volts at Riverside. In addition to these circuits, two 33,000-volt circuits were run to the Bethlehem Steel Company at Sparrows Point, and a 33,000/4,150-volt transformer bank was installed to supply local distribution service from Riverside.

In 1940 the steam generating capacity in Baltimore consisted mainly of the Westport and Gould Street plants. With the completion of the installation of a 25,000-kw superposed unit at Westport in 1940, the Westport plant had 125,000 kw of 25-cycle and 65,000 kw of 60-cycle capacity. In 1941 a 60,000-kw condensing unit was put in service at the same location.

The Gould Street plant had 72,000 kw of 60-cycle capacity. In addition, the small standby Pratt Street plant had 20,000 kw of 25-cycle capacity available under certain conditions. As the Pratt Street plant is primarily one of the sources of steam for the district steam-heating system, at times this imposes a limitation on the amount of steam available for driving the 20,000-kw unit.

A completely new steam-electric generation plant was erected at Riverside. The initial installation consisted of a 60,000-kw condensing unit which was placed in service in December 1942. A second unit of the same size was installed and began operation in April 1944. The two Riverside units substantially duplicate the 60,000-kw condensing unit installed at Westport in 1941.

An important element in the company's electric-transmission system is the 110,000-volt "ring" that surrounds Baltimore at a radius of some ten miles. Riverside Station is its eastern terminus, and the western terminus is at the Westport Station; between these stations there are 33,000-volt cables, thus forming a complete circle of 60-cycle transmission around the

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Essential substance of a paper presented at a joint meeting of the Maryland Sections of AIEE and American Society of Mechanical Engineers in May 1945.



G. P. Fallon is assistant electrical engineer, and F. W. Quarles is assistant to the superintendent, power production stations, both with Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Md.

**Figure 1. View of a 1,500-horsepower 3,600-rpm variable - speed boiler-feed - pump motor**

entire city. There are 110,000-volt extensions from the ring to provide electric service to outlying districts. At Riverside and Westport the ring connects, through transformers, with the 220,000-volt transmission circuits from Safe Harbor.

The outdoor 33,000-volt substation bus, installed in 1937, and designed for expansion as a generating station bus consists of a conventional steel structure with a sectionalized double bus and two oil circuit breakers per circuit. Initially, the two original sections were joined by means of disconnecting switches with provision that as added generation raised the short-circuit duty, the double secondary windings of the 220,000/33,000-volt transformers could serve as a reactance tie between the bus sections. Expansion beyond two generators at Riverside will call for additional sections joined to the original bus by means of reactors.

The 220,000-volt line from Safe Harbor is connected directly to the high-voltage windings of the 126,000-kva transformer bank through an air-break switch and single-pole remote-operated disconnecting switches. The transformer bank consists of four single-phase units having a self-cooled rating of 28,000 kva each and an air-blast rating of 42,000 kva each. Windings are arranged for star–star connection with a delta tertiary winding. Each transformer has two separate 33,000-volt windings, and each winding is connected to a separate section of the 33,000-volt bus through oil switches. This arrangement provides reactance between the two bus sections. Each of the transformers, which are of the outdoor oil-filled load-ratio-control type with radiators, is located over a large pit filled with crushed stone and is provided with a permanently piped fire-fighting system having an array of nozzles for fighting transformer fires with water. The pit is provided with an overflow pipe which is in the form of an inverted siphon to remove any water discharged by the system and still contain the oil in case of a transformer tank failure. There are also vertical motor-driven sump pumps for completely draining the pits. The transformers are equipped with the usual nitrogen gas seal with automatic pressure-regulating equipment. The spare transformer is provided with remote-operated disconnecting switches to allow its substitution for any unit in the bank.

Each of the two 110,000-volt circuits leaving Riverside, one of which is part of the ring around the City of Baltimore and the other of which terminates at the Gunpowder substation, is supplied by a 53,333-kva three-phase transformer from the 33,000-volt bus. These transformers are also connected star–star with delta tertiary windings.

Inasmuch as the armature windings of the two generators at Riverside are arranged for 13,800-volt service, each unit is provided with a three-phase auto-transformer having a self-cooled rating of 60,000 kva and an air-blast rating of 80,000 kva for delivering generator power direct to the 33,000-volt busses.

The arrangement of all circuits connecting to the 33,000-volt busses is such that a bus differential-relay protective system can be used for isolating a faulty bus section with a minimum effect on load or power supply.

Adjacent to the switchyard is an assembly house with a permanent track system extending to all six of the major transformers and a transfer car for moving the transformers into the house for assembly or major repairs.

### MAIN GENERATORS

Each generator, including the Westport machine, was initially rated by the manufacturer at 50,000 kw, 62,500 kva, for operation at one-half-pound gauge hydrogen pressure and at 50,000 kw, 71,875 kva, for 15-pound gauge hydrogen pressure. It has been demonstrated conclusively in operation that these units are capable of carrying 60,000 kw each, and, consequently, they are rated at this figure. The kilovolt-ampere ratings are unchanged, with corresponding power factors of 96 and 83.3 per cent, respectively. The main generators are of compact construction, as they are designed for operation at 3,600 rpm with hydrogen as the cooling medium. The hydrogen is circulated by fans directly attached to the rotors and is cooled by four coolers mounted in the generator housing. Because of the corrosive nature of the harbor water that is used for cooling, it was necessary to construct the cooler tubes of a copper–nickel alloy. The fins on the tubes, however, are of standard copper construction.

The armatures of both generators are resiliently mounted by means of flexible bars in the same manner as that of the 25,000-kw superposed unit at Westport, which was a pioneer installation of this design. The resilient mounting method prevents a large part of the 120-cycle vibration produced in the armature core of 3,600-rpm generators from being transmitted to building foundations and thence to steel members and parts often resonant or nearly resonant to this frequency.

Each armature has all six leads of the three phases of the winding brought out and is star-connected with a current transformer in each lead to the neutral. Each neutral is grounded through a reactor which limits the ground current caused by a fault to a satisfactory value. The main leads consist of four 2,500,000-circular-mil cables per phase connecting directly to the 13,800-volt winding of the step-up transformer. These cables are physically arranged to equalize reactance and current distribution among the individual conductors.

Only the 33,000-volt windings of the 60,000/80,000-kva-unit transformers are provided with oil circuit breakers. These breakers are located in the 33,000-volt outdoor bus structure and connect the generators directly to the 33,000-volt busses.

The main field is wound with aluminum conductors in order to reduce the amount of mass rotating at high speed and thus diminish the stresses.

### MAIN CIRCUIT RELAYS

In general, main power-supply circuits of the Baltimore system are arranged so that the loss of a circuit does not seriously impair power service.

The two Safe Harbor–Baltimore 220,000-volt circuits are operated in parallel on the low-voltage sides of the transformers at both ends, so that the loss of one circuit reduces but little the flow of Safe Harbor power to Baltimore. At Baltimore one circuit terminates at Westport and the other at Riverside, and they are tied together by the 33,000-volt cables which extend from Westport to Gould Street to Riverside and by the 110,000-volt transmission ring which extends from Westport around the city to Riverside.

The 220,000-volt Safe Harbor-to-Riverside line is equipped with high-speed carrier-current relaying which is arranged to cause instantaneous tripping of the oil switches on the low-voltage side of the transformer banks at each end when a fault occurs at any point on the line. The transformers are protected for breakdown with high-speed transformer differential relays which trip the 33,000-volt oil switch and block the carrier-current signals in order to permit relays at Safe Harbor to function and to clear the line at that end.

The two 110,000-volt transformers and their transmission lines are protected by high-speed relays which function instantaneously for phase-to-phase and phase-to-ground faults over a large portion of the lines, with inverse-time overload relays set to co-ordinate with the relaying and fuses at stations supplied from these lines. These transformers also are equipped with differential relays which operate on trans-

former breakdown to trip the 33,000-volt supply breakers and block automatic reclosing.

The 33,000-volt tie cable circuits (three three-phase cables per circuit) to Gould Street and Westport are equipped with special high-speed differential relays which trip the oil circuit breakers of the faulted circuit and indicate which cable of the group of three has failed. In addition, there are inverse-time overcurrent relays which protect against faults between the bus and the cable reactors and which also serve as backup relays.

Sensitive generator differential relays are applied to the 60,000-kw generators, and slightly less sensitive transformer differential relays are applied to the combination of both generator and transformer, thus serving as backup to the generator relays. Either of these relays trips the 33,000-volt generator breakers, and corresponding generator field breaker.

### AUXILIARY GENERATOR

The decision to pattern the Riverside design after that of the 60,000-kw installation at Westport implied the like use of an auxiliary generator directly connected to the main-generator rotor to act as the normal source of power for certain auxiliaries, the loss of which will promptly shut down the boiler–turbine combination. By a slight modification of the Westport design, the size of the auxiliary generator was increased to 4,000 kw in order for it to carry all the essential auxiliaries of its own boiler–turbine combination.

Each of the auxiliary generators at Riverside has a closed system of air cooling and is rated 4,000 kw, 5,000 kva, at 2,300 volts, 60 cycles. The coolers are of the finned type and have copper–nickel tubes in which harbor water flows from the same source as that feeding the main-generator hydrogen coolers. The auxiliary-generator rotor is coupled to the main-generator rotor so that the voltages of each machine are in phase at zero load.

In starting, the essential auxiliaries receive their power from the station bus through a service transformer, and the auxiliary generator is paralleled immediately after the synchronization of the main unit. In shutting down, the transfer of auxiliary load to the service transformer and the subsequent opening of the auxiliary-generator breaker precedes that of the main-generator breaker.

### EXCITERS AND VOLTAGE REGULATORS

The high degree of reliability of auxiliary power furnished by the direct-connected auxiliary generators made feasible the use of low-speed induction-motor-driven exciter sets for the main and auxiliary fields. Each normal exciter set consists of a 500-horsepower 890-rpm induction motor driving a 220-kw main field exciter; a 30-kw auxiliary field exciter; and a $7^1/_2$-kw pilot exciter which serves the fields of the other two exciters. The station emergency exciter set acts as a spare for the two present units but is somewhat larger in capacity to provide for a moderate increase in unit size for future machines. This exciter consists of a 700-horsepower motor driving a 300-kw main exciter, a 50-kw auxiliary exciter, and a $7^1/_2$-kw pilot exciter.

An Amplidyne voltage regulator is provided in conjunction with each main field exciter. This device, a generator of special construction driven by a five horsepower motor, is designed to maintain the main-generator voltage at the correct value.

### AUXILIARY TRANSFORMERS AND BUSSES

There are two 6,000-kva 34,500/2,400-volt three-phase 60-cycle outdoor-type oil-filled self-cooled transformers for supplying power to the plant auxiliaries from the 33,000-volt bus. One of these connects to the 2,300-volt transfer bus. Normally, this transformer is used only during the starting period, when the auxiliary generator is not at full speed, to furnish power to the busses supplying essential turbine and boiler auxiliaries, or when it is desired to start a motor having a high current demand. For example, the transformer and auxiliary generator are operated in parallel during the starting of the large boiler-feed-pump motors. This transformer also is used as an emergency supply for the plant service bus.

The second transformer normally is used to supply the 2,300-volt plant service bus to which are connected those auxiliaries which may be stopped for a short time without causing much difficulty other than a delay of service. However, it is possible to connect this plant service bus to the transfer bus just described for supplying both types of services under unusual conditions. There are three 440-volt busses supplied from corresponding 2,300-volt busses by means of transformers. Small auxiliaries of each boiler and turbine are supplied from a 440-volt bus connected by a 300-kva transformer bank to the 2,300-volt unit bus which, in turn, is supplied from the auxiliary generator of the associated unit. The 440-volt plant service bus differs from the comparable 2,300-volt bus in that it has two sections, each supplied by a 1,000-kva transformer, and it serves the small auxiliaries.

### RELAYING OF STATION AUXILIARIES

The auxiliary generators have differential relays which trip their respective main and field breakers for armature breakdown. They also have inverse-time overcurrent relays and undervoltage relays which trip their main breakers. The tripping of the auxiliary-generator main breaker by any of the relays previously mentioned also automatically closes the tie breaker between the unit bus and the transfer bus which is supplied by a service transformer. If low voltage persists on the unit bus after this operation, a second low-voltage relay trips breakers which shut down the forced- and induced-draft fans, pulverizing mills, and their blowers which are supplied from this bus. This is done not only to protect the motors from extreme low voltage but to minimize chances of fuel explosion in the boiler.

Each of the two 6,000-kva service transformers has inverse-time overcurrent and instantaneous differential-relay protection. The two 1,000-kva and two 300-kva transformers supplying the 440-volt service busses have inverse-time overcurrent relays. Undervoltage on a 440-volt bus causes tripping of the normal supply breaker and closing of the tie breaker to the plant service bus, thus providing restoration of service from another source.

In general, the 2,300-volt plant feeder

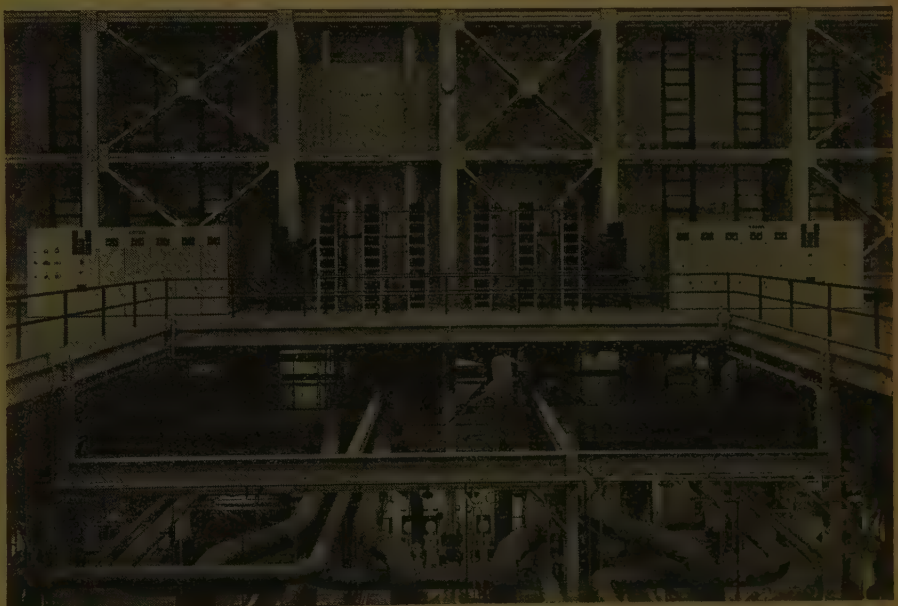


**Figure 2. East side of the turbine room showing in background 2,300-volt turbine bus and switchgear enclosure and boiler-feed-pump controllers**

breakers are supplied with induction-type inverse-time overcurrent relays, while the 440-volt feeder breakers have built-in magnetic overcurrent trip mechanisms with oil-film time-delay attachments.

### 2,300-VOLT AND 440-VOLT CIRCUIT BREAKERS

All circuit breakers on the 2,300-volt busses have 150,000-kva rupturing capacity and are of the air-break solenoid-operated trip-free type, housed in individual steel cubicles which are arranged in groups. The circuit breakers attached to the 440-volt busses have an interrupting capacity of 50,000 amperes and are of the air-break type, housed in cubicles and protected by interlocks.

### ELECTRIC PRECIPITATORS

In each of the two flue gas streams leaving each boiler there is a precipitator for the electrostatic removal of flue dust. The electrodes of each precipitator are supplied with high-voltage rectified current obtained from a 75,000-volt transformer and from a synchronous motor-operated full-wave mechanical rectifier (spark-gap unit).

Each precipitator has inlet and outlet electrodes so connected that one receives the positive half wave and the other the negative half wave of the rectified power. The precipitators are supplied from the 440-volt plant service bus and are equipped with a spare transformer and rectifier unit which can be substituted for any of the normally operating units.

### MOTORS AND CONTROL

In general, motors of 60-horsepower capacity and larger are supplied from 2,300-volt circuits. Those between 60 and 1 horsepower are supplied from 440-volt circuits and those below one horsepower from the 120/208-volt lighting circuits. The coal-handling equipment deviates from this plan in that 2,300-volt service is delivered to the site and stepped down for the simple reason that it is more economical to use 440-volt controllers.

Wherever feasible, rugged full-voltage-starting sleeve-bearing squirrel-cage induction motors have been used to drive auxiliaries. This policy extends up to and includes the 1,500-horsepower dual-drive emergency boiler-feed pump.

In addition to the 1,500-horsepower emergency boiler-feed pump, 2,300-volt squirrel-cage motors are used in the following sizes: 250 horsepower for forced-draft fans, 75 horsepower for pulverizer mills, 60 horsepower for primary-air fans, 250 horsepower for vertical circulator pumps, 700 and 500 horsepower for exciters, 200 horsepower for ash-sluice pumps and 100 horsepower for air compressors.

Wound-rotor motors are used in some applications to provide the adjustment of pump and fan speed necessary for the accurate control of a large unit installation without encountering the mechanical difficulties arising from various types of variable-speed couplings, vane controls, throttling means, and the like. These wound-rotor motors vary in size from 1,500 horsepower on boiler-feed pumps down through 400 horsepower on induced-draft fans, to 150 horsepower condensate-pump motors, and to miscellaneous applications as small as 25 horsepower.

The variable-speed motors driving the normal boiler-feed pumps are believed to be the first wound-rotor motors built in the United States for as large a capacity as 1,500 horsepower at 3,600 rpm. They are used mainly to reduce the high pressure drops across the boiler-feed-control valves and the resulting maintenance costs and outages, both of which would be encountered by the use of constant-speed motors. There is also less wear on the pump and slightly better power economy by the use of the variable-speed drive. The controllers for these motors are the drum type with pilot-motor-driven cams which provide 19 balanced operating points. Because of the importance of the service, these controllers have extra direct-connected pilot motors to substitute for the regular motors in case of need.

Each of the two induced-draft fans per boiler is driven by a wound-rotor motor having a capacity of 400 horsepower at full speed of 885 rpm. The controllers for these motors are also of the drum type with pilot-motor-driven cams which provide 13 balanced points, and normally the two controllers are mechanically connected to provide simultaneous operation. Each controller has its own pilot motor for individual use, if desired.

The two condensate pumps per unit are rated at 150 horsepower for full speed of 1,165 rpm and are controlled by hand-operated drums with cams giving 13 balanced points.

The control of the motors of the coal-conveying equipment is interlocked to prevent coal from piling up on receiving equipment when the equipment is not running. As there are four modes of operation of this equipment, a four-position sequence-selector switch is provided to set up adequate circuit interlocking. The control of the motors of the fans and mills of the boilers likewise is interlocked to protect against fuel explosions or discharge of hot gases into the boiler room.

### D-C SERVICE AND BATTERY

The control power for operation of circuit breakers, motor-operated valves, and other devices of the essential type is obtained from a 250-volt d-c bus on which floats a 400-ampere-hour storage battery. The battery is center-tapped and upon failure of the a-c lighting supply serves as a source of power for the emergency or essential lighting circuits. Because of the center tapping, the a-c motor-driven battery-charging set is of the two-unit type having two 20-kw 125-volt shunt-wound generators with voltage maintained at the correct value by an electronic voltage regulator.

The battery booster set also has two shunt-wound generators for interposition between the bus and the battery, so that the bus voltage may be held at 250 volts while the battery is being charged. In case of abnormal lowering of bus voltage while the battery is being charged by the booster, the battery breaker closes and the booster breaker opens, thus connecting the battery directly to the bus.

The turbine-room crane, elevator, and coal-belt magnetic pulley are supplied with 250-volt d-c power from a 75-kw motor generator set, with provision made for supplying this service from the emergency main exciter in case of an outage of this set.

### PLANT-LIGHTING CIRCUITS

Most of the main lighting circuits which are 120 volt 60 cycle are supplied through single-phase 2,400-to-120-volt transformers connected to the 2,300-volt three-phase service bus. The secondary windings of these transformers are star-connected with grounded neutral and provide 208-volt three-phase power for miscellaneous fractional-horsepower motors. Emergency lighting circuits normally are supplied by 120-volt a-c power, and, when a deficiency of alternating voltage occurs, they are transferred to the battery by an automatic-change-over panel.

### COMMUNICATION FACILITIES

Two main communication systems are provided at important operating locations in the boiler house and turbine room. The first is that of regular Bell System automatic dial telephones connected to a local satellite board which, in turn, is connected to the company's main board by trunk lines. The other system of communication is entirely local, being that of telautographs arranged so that all stations write in unison and any station can act as a sender. Both of these communication systems reach the switchboard operator in the control house, and, in addition, he has available a private line to a third separate communication system connecting with the electric load dispatcher.

### CONCLUSION

The design of the electrical facilities at Riverside was carried out by the electrical engineers department of the company with the co-operation of the operating departments, and the aim throughout has been to obtain a high degree of reliability, together with low operating and maintenance expenditures, with proper consideration being given to fixed costs. The exceptional reliability attained is well demonstrated by the fact that for the year 1944 the generator outage factor for unit 1 was 0.21 per cent and for unit 2 was 0.50 per cent. Unit 1 was operated for more than 90 per cent of the hours in the year 1944, and unit 2 was operated for nearly 94 per cent of the hours remaining in the year after its installation.

# Application of Electronics in the Electric Power Industry

C. F. WAGNER
FELLOW AIEE

**The role of the mercury-arc rectifier in power conversion, the use of ignitrons as electronic exciters, and the diversified applications of the precipitator are discussed at length in this article.**

THE APPLICATION of electronics in the electric-power industry has become wide-spread and this expansion has resulted in greater power transmission and more flexible operation of power systems. Electronic developments not only have helped the industry meet wartime demands but also have assured it a future market for its increased power and efficiency.

### METAL-TANK RECTIFIERS

Many contributing causes for the expanding uses of electronic devices in the power field can be listed in a survey on electronic applications. The introduction of the steel tank to mercury-pool-type rectifiers was probably the greatest contributing factor toward bringing the mercury-arc type rectifier into the power conversion field. Its acceptance is due to its low maintenance and low outage factor. Its efficiency, particularly at light loads and in the higher-voltage classes, shows to advantage over the rotating types of converters. Contrasted with rotating machines, metal-tank rectifiers produce less vibration and less noise. A survey of the period from 1920 to 1940 shows that approximately 500,000 kw of mercury-arc rectifiers were installed in the United States in the transportation, electrochemical, and power fields. These consisted largely of multianode tank type of construction. During this time, work was done on a single-anode tank and the first rectifier of this type, known as the ignitron, was introduced commercially in 1937. The advantages of the single-anode rectifier compared with the multianode rectifier, soon made it the most popular type of device. In the period from 1940 to the present time approximately 3,800,000 kw of all types were installed, largely in the electrochemical field in Canada and the United States. Of these, 3,200,000 kw were ignitrons.

Today the mercury-arc rectifier has practically displaced the rotary converter in new installations requiring conversion. In addition to the electrochemical field, it also finds application in such industries as mining, railway, steel, and paper, and also in the power field where a small source of direct current is required in the process of converting d-c distribution systems to a-c networks.

### D-C TRANSMISSION

In many fields the word *electronics* has been the watchword for unrestrained visionary engineering. In no branch has a little engineering development unleashed such optimistic forecasts as in d-c transmission. This state of mind created a feeling of uncertainty in the industry concerning all forms of transmission of power.

D-c transmission consists essentially of generation at alternating current, transformation from generation to transmission voltage, rectification to high-voltage direct current, transmission at high-voltage direct current, inversion at the receiving end to high-voltage alternating current, transformation again to low-voltage alternating current, from which it can be distributed. The two advantages that are usually claimed for d-c transmission are first, the removal of the stability problem and second, the more economical utilization of the line. Considering the first point, for d-c transmission, power is transmitted by voltage drop and the stability problem it practically eliminated. As to economy is is frequently assumed that for a given line construction and insulation, the d-c voltage across a string of insulators at which the line can operate is equal to the crest value of the corresponding line to neutral voltage of the a-c line. On this basis the d-c line can transmit at least 40 per cent more power than the a-c line for the same loss. Actually, the problem is not so simple. For voltages at which d-c transmission might be attractive, the line insulation is determined largely by considerations arising from the surges resulting from lightning. Under normal conditions, the distribution of voltage along a string of insulators for direct current may be more or less uniform than for alternating current, depending upon the amount and distribution

**Figure 1. Westinghouse Electric Corporation 5,000-kw electronic frequency changer**

*External view showing transformers, reactors, and switchgear*

Essential substance of an address delivered before the AIEE Montreal Section, November 10, 1944.

C. F. Wagner is manager, central station engineering, industry engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.

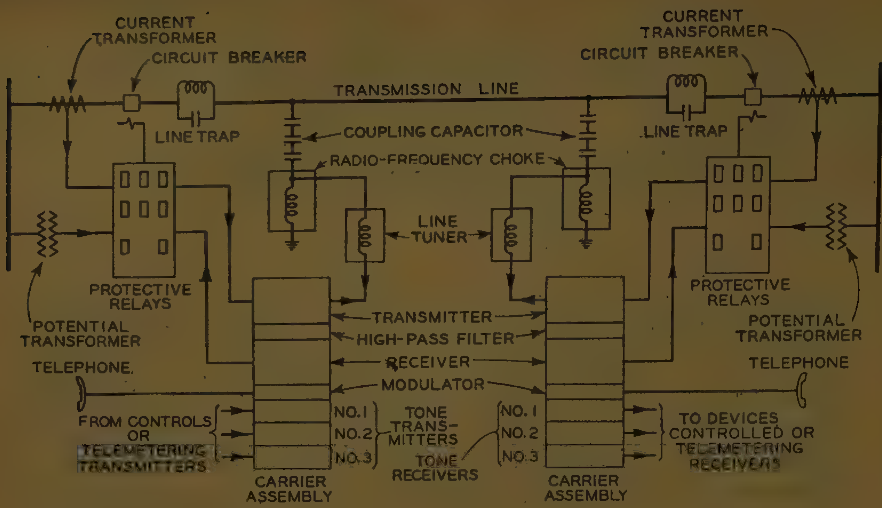



**Figure 2. Schematic diagram of carrier-current system**

of dirt upon the insulators. For alternating current not all faults develop into power arcs as would be the case for direct current. Until operating experience is collected on some of these questions, a true comparison is not possible.

D-c transmission requires more equipment than a-c transmission—equipment less tried by operational experience. If the equipment were fully developed, the balancing point between the cost of a-c and d-c transmission from present estimates would be somewhere in excess of 300 miles and blocks of power in excess of 300,000 kw. Power of this magnitude requires rectifiers and inverters capable of operating at voltages of the order of 200,000 volts. Tubes of about 15,000 to 20,000 volts operating at about 1,000 kw each are available today. Several hundred of such tubes, connected in series and multiple, would be required at each end of the line. The cost of conversion equipment almost limits the system to straight-away transmission without tap points. Reactive kilovolt-amperes cannot be transmitted but must be supplied at the receiving end, which may require the installation of additional synchronous condenser capacity.

Because of the higher cost per mile of cable, the benefits of high-voltage d-c transmission are more pronounced in cable transmission than for open lines. On account of the marked reduction in dielectric loss, a given cable can operate at much higher direct than alternating voltage. These two factors justify consideration of d-c transmission for much shorter cable distances than for open lines. Where a tie line is intended to connect systems of different frequencies, the added advantage of frequency conversion justifies d-c transmission for shorter distances, lower voltage and lower power for either open lines or cables.

As improvements are made that are conducive to d-c transmission other improvements are simultaneously being made in a-c transmission. Thus, with improvements in high-speed clearing of faults and reclosing, the transient limits are approaching the steady-state limits. Series capacitors can also be expected to increase transient stability limits. Who can tell what further developments lie on the horizon? Thus, the competitive situation for d-c transmission is continually becoming more severe.

### FREQUENCY CONVERTERS

Frequency converters are similar to d-c transmission systems except that the transmission line is omitted. They may be used to provide a flexible tie between two systems. The frequency of one system can change over wide limits without affecting the other. This advantage is particularly applicable to tie 60-cycle utility systems with 25-cycle steel-mill systems. The latter have very high sudden demands for power and if connected rigidly to the 60-cycle system transmits the demand to it. Figure 1 shows the external view of a laboratory 5,000-kw set. The experience obtained with electronic frequency changers should be of enormous value in providing the experimental foundation for d-c transmission. With this information as a background it will be possible to speak with definite and less imaginative engineering knowledge than has been the case in the past.

### EXCITERS

Exciters have had an availability factor comparable to that of the main machine. However, since it is not the principal element in the unit, exciter troubles have been emphasized beyond their real importance. This is particularly true of direct-connected exciters, maintenance of which requires shutdown of the whole unit. This philosophy has engendered sympathetic consideration of the electronic exciter as a means of supplying excitation. Being independent of the main unit any servicing that might be required can be done without shutting down the whole unit.

Ignitrons with their vast background of experience are being applied as electronic exciters. The time lag of the rotating exciter is eliminated because the voltage reaches the ceiling value within a quarter cycle, the only lag being that due to the regulator. With this type of excitation special consideration must be given to the voltage supply. In one case this is taken from the same supply as the auxiliaries. Consideration has also been given to providing a separate synchronous machine on the shaft of the machine. A third proposal, one unit of which is being supplied on a particular job, is to connect the rectifier across the terminals of the main machine. In this case any drop in system voltage, such as might result from a fault, produces a drop in voltage applied to the main field winding and at an instant when it is most undesirable. To obviate this difficulty a series compensator is placed in each phase next to the neutral which increases the rectifier voltage at times of a system short circuit. This unit has been tested in the laboratory and will be given more extensive tests in supplying the excitation to one of the units in the Westinghouse high-power laboratory. By this means the essential conditions met in practice may be simulated. The electronic excitation system costs appreciably more than a direct-connected exciter or a separate motor generator set. The extra cost must be justified by increased reliability or higher response.

Inquiries have also been made on

**Table I**

| $\frac{\Delta F}{f}$ | $J_0$ | $J_1$ | $J_2$ | $J_3$ | $J_4$ | $J_5$ | $J_6$ | $J_7$ | $J_8$ | $J_9$ | $J_{10}$ | $J_{11}$ | $J_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | | | | | | | | | | | | |
| 0.2 | 0.99 | 0.10 | 0.005 | | | | | | | | | | |
| 0.5 | 0.94 | 0.24 | 0.03 | | | | | | | | | | |
| 1.0 | 0.77 | 0.44 | 0.11 | 0.02 | 0.002 | | | | | | | | |
| 2.0 | 0.22 | 0.58 | 0.35 | 0.13 | 0.03 | 0.01 | | | | | | | |
| 5.0 | −0.18 | −0.33 | 0.05 | 0.36 | 0.39 | 0.26 | 0.131 | 0.05 | 0.02 | 0.06 | 0.15 | 0.04 | 0.08 |
| 10.0 | −0.25 | 0.04 | 0.25 | 0.06 | −0.22 | −0.23 | −0.01 | 0.22 | 0.32 | 0.29 | 0.21 | 0.12 | 0.09 |

means of eliminating pilot exciters. Two of the proposals to accomplish this end are (1) improvement in stability of the direct-connected main exciter and (2) replacement of the pilot exciter by a permanent magnet synchronous machine with a rectox rectifier to supply the direct current.

### POWER-LINE CARRIER

Because of its great versatility, power-line-carrier equipment is attaining greater and greater acceptance by utilities. While

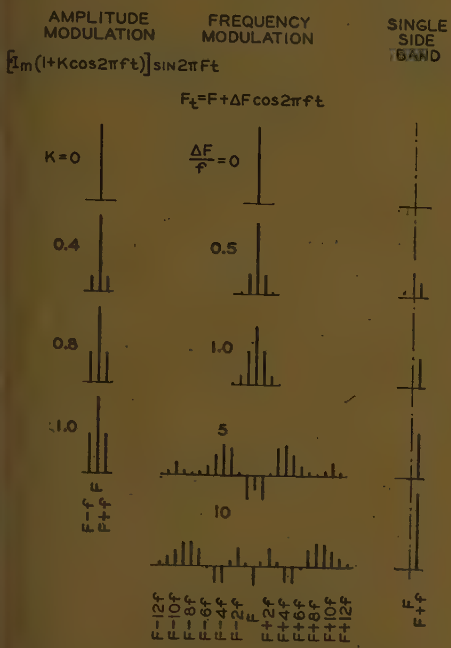



Figure 3. Distribution of side bands

it was originally introduced for communication purposes, it has expanded now to include relaying, telemetering, supervisory control, and load control. Figure 2 shows a schematic diagram of a complete system adaptable to several functions. Standard rack-mounted carrier components are now available from which combinations can be selected to perform exactly the functions desired with a minimum of equipment and a maximum of convenience and flexibility.

Power-line carrier is a high-frequency (50 to 150 kilocycles) current that is fed into the power line through coupling capacitors which to the lower power frequency are essentially insulators. When desired, the loss of carrier-frequency energy can be minimized by means of line traps, that look much like current-limiting reactors but which can be tuned to offer high impedance to carrier currents. Line traps are used principally when the carrier is used for relaying purposes to prevent short-circuiting of the carrier for faults outside of the section of line being protected.

Three types of power-line carrier are used today; namely, amplitude modulation, frequency modulation, and single side-band or suppressed carrier. In amplitude modulation the amplitude of the carrier current is modulated in response to the voice fluctuations. Since these fluctuations can be resolved into frequencies within the speech range of 3,000 cycles per second, the performance for any one audio frequency can be represented by the expression

$$I_t = I_m[(1+K\cos 2\pi ft)]\sin 2\pi Ft \qquad (1)$$

in which $F$ is the carrier frequency, $f$ the audio frequency, $I_m$ the amplitude of the unmodulated carrier, and $KI_m$ the amplitude of the audio fluctuations. The expression in brackets can be viewed as the amplitude of the carrier current, which is, of course, varying at audio frequency. This expression can be transformed to

$$I_t = I_m \sin 2\pi Ft + 0.5I_m \sin 2\pi(F-f)t + 0.5KI_m \sin 2\pi(F+f)t \qquad (2)$$

The second term is the lower side band at frequency $(F-f)$, lower than the carrier by the audio frequency and the third term is the upper side band, at frequency $(F+f)$, greater than carrier by the audio frequency. Figure 3 shows how the side bands vary as the modulation increases for a given audio frequency.

In frequency modulation systems the instantaneous value of the carrier frequency changes in response to the audio modulation. The transmitted wave can be regarded as the projection of a vector of constant amplitude that rotates with nonuniform speed—the audio frequencies being superposed upon the constant-carrier frequency. If $\Delta F$ is the increment in transmitted frequency then the instantaneous angular velocity or speed of this vector (for a given audio frequency) is

$$2\pi F_t = 2\pi F + 2\Delta F\cos 2\pi ft \qquad (3)$$

the instantaneous position of the vector (or phase position) is

$$\alpha = \int^t (2\pi F + 2\pi\Delta F\cos 2\pi ft)dt$$
$$= 2\pi Ft + \frac{\Delta F}{f}\sin 2\pi ft \qquad (4)$$

Then the instantaneous value of the transmitted current is

$$I_f = I_m \sin\alpha$$
$$= I_m \sin\left[2\pi Ft + \frac{\Delta F}{f}\sin 2\pi ft\right] \qquad (5)$$

This expression can be expanded into a spectrum distribution.

$$I_f = I_m\left\{J_0\left(\frac{\Delta F}{f}\right)\sin 2\pi Ft + J_1\left(\frac{\Delta F}{f}\right)[\sin 2\pi(F+f)t - \sin 2\pi(F-f)t] + J_2\left(\frac{\Delta F}{f}\right)[\sin 2\pi(F+2f)t + \sin 2\pi(F-2f)t] + J_3\left(\frac{\Delta F}{f}\right)[\sin 2\pi(F+3f)t - \sin 2\pi(F-3f)t] + \ldots\right\} \qquad (6)$$

Thus it can be seen that the varying-frequency, constant-amplitude wave consists of one component of carrier frequency and an infinite number of side bands. The magnitudes of the carrier wave and side bands are dependent upon the ratio of the increment in carrier frequency to the audio frequency. For a given audio frequency, the side bands change as the intensity of the sound producing the effect increases (or the equivalent, as $\frac{\Delta F}{f}$ increases). Table I shows this variation.

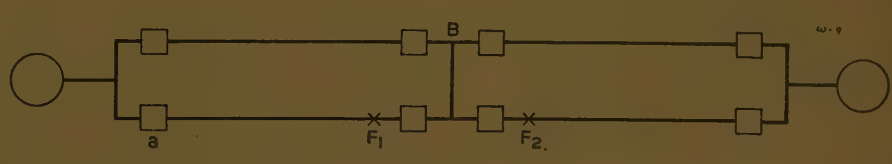
Figure 3 shows how, for a given audio frequency, the side bands change as the intensity of the sound producing the effect increases (or the equivalent, as $\frac{\Delta F}{f}$ increases.)

In single-side-band carrier both the carrier wave and one of the side bands are suppressed and only the remaining side band is transmitted. At the receiving end the transmitted side band is recombined with a locally generated reference carrier to reproduce the original signal. By this scheme it is sufficient to transmit only one intelligence-bearing side band. It differs from both amplitude modulation and frequency modulation in that when no intelligence is being transmitted there is likewise no energy being transmitted. The transmitted side band varies with the intensity of the signal for a given audio frequency.

In comparing these different types of carrier, two principal factors should be considered; namely, the crowding of the carrier spectrum and the effect of interference. By its very nature frequency modulation covers a wide frequency spectrum. In the wide-band system used in frequency-modulation broadcasting this is no particular disadvantage because it is used only in the high-frequency range. Under these conditions a high signal-to-noise ratio is obtained. For carrier work the total available range of frequency is

Figure 4. Transmission circuit

*Breaker at A must discriminate between fault at $F_1$ and $F_2$*



only 50 to 150 kilocycles and thus the same gains are not attainable. One is restricted to values of $\frac{\Delta F}{f}$ of about 1.0 for an audio frequency of 3,000 cycles and while some gain in signal-to-noise ratio is obtained the frequency band is also increased. With single side band on the other hand very considerable gain is obtained in signal-to-noise ratio without the attendant increase in frequency band width of either amplitude modulation or frequency modulation. For most cases amplitude-modulation schemes are satisfactory but for systems where spectrum crowding is a problem or on long lines where attenuation is high, single side band is the answer. This is of particular value when large numbers of communication channels are required since it requires a smaller portion of the carrier spectrum for each channel.

*Communication.* Because of the ease with which carrier communication can be accomplished over long distances, it is ideally suited for co-ordinating the operations of remotely located points in extensive systems and can be used for dispatching services and for conducting normal and emergency operations. The equipment available practically duplicates the service obtainable in automatic telephone exchanges. Due to the more substantial construction justified for power lines than for telephone lines, communication by carrier is less likely to be interrupted by natural causes. Communication is usually maintained even though a fault occurs on the transmission line. Particularly for long distances, carrier represents a real saving as compared to separate cables. In some systems a single carrier channel is used to carry on conversation both ways. The function of transferring from transmission to receiving in the "push-to-talk" system is done manually. However, this task can be done automatically by means of an electronic transfer unit. The two-frequency or duplex system is often used where direct communication is required between two points only. In this system speech in one direction is transmitted at one frequency while speech in the other direction is transmitted at another frequency. Both communications can be carried on simultaneously, making the transfer from transmission to reception unnecessary. The duplex system lends itself for carrying into a private-branch-exchange board at either end to serve as a link in a more extensive communication system.

*Relaying.* Rapid clearing of faults on transmission lines is desirable because it promotes stability of the system, permits faster reclosing, results in less damage to equipment from arcing, and decreases the probability of more than one phase becoming involved in the fault. Carrier-pilot protection offers a medium by which this can be done. Referring to Figure 4, it is difficult for the relays controlling breaker $a$ to discriminate between a fault at $F_1$ and $F_2$ close to bus $B$. Naturally, breaker $a$ should open for a fault at $F_1$ but not for a fault at $F_2$. Either sufficient lag must be introduced into the operation of $a$ to permit the proper breaker at bus $B$ to function and thus change the response quantity at $a$ or additional information must be transmitted back to $a$ by carrier to permit discrimination. For all faults outside of the section under consideration a blocking signal is transmitted back to $a$ by carrier that prevents tripping of that breaker. For faults within the section no signal is transmitted and $a$ opens almost instantaneously. By this system simultaneous tripping of both breakers at the ends of the faulted section and consequent clearing of the fault can be achieved in from one to three cycles.


**Figure 5. A charging unit (right) and a collecting unit (left) of a Precipitron**

*Telemetering and Supervisory Control.* Telemetering is the indicating or recording of a quantity at a location remote from the point at which the quantity exists. In power systems the quantity most frequently telemetered is kilowatts, although other quantities, such as voltage, phase angle, reactive power, hot-spot temperature and tap-changer positions can be similarly recorded. Thus, any desired quantity can be brought to a central location for the use of a load dispatcher. All the information is at his disposal for operation of the system. Telemetering schemes or their equivalent can also be used in conjunction with automatic load-control equipment. With carrier supervisory control remote substations can be controlled by standard equipment. A single operator can trip or close selected circuit breakers, start or stop motors, condensers, or generators, switch capacitors or any of an innumerable set of operations.

*Combination of Functions.* Many of the functions just outlined can be performed on a single carrier channel. Carrier relaying systems are available that require the use of the carrier only during the duration of the fault. The channel is thus free at other times and can be used for other purposes. Under normal conditions, the unmodulated carrier can be keyed directly by impulse telemetering equipment, and if tone modulation is used, can record as many as ten quantities. If it is permissible to interrupt their recording, "push-to-talk" telephone communication can be cut into the carrier. If fewer tone channels are required, filters can be installed to cut off all audio frequencies below 500 cycles for tone modulation, and those above used for voice communication, still retaining acceptable speech quality, without interruption to the tone channels below 500 cycles which can provide four tones. With tone modulation, all the tones can be used simultaneously.

### ELECTROSTATIC PRECIPITATION

Electrostatic precipitation has long been recognized as the outstanding means of cleaning fine particles from a gas. For years the Cottrell system has been used for the reclamation of flue dust in smelters. In this system alternating voltage of values as high as 100,000 volts is rectified by means of rotating electrodes. The negative terminal of the rectifier is connected to a heavy wire between vertical metal plates spaced 10 or 12 inches apart. The dust-laden air is passed between these electrodes. The dust particles receive a negative charge from the corona and are deposited against the positive plates. This system has not come into use for ventilating systems because the high-voltage corona discharge generates ozone and oxides of nitrogen which are toxic for human consumption. In addition, the power to maintain a continuous discharge in the large spaces utilized by this method requires bulky and expensive transforming and mechanical rectifying equipment.

A new type of precipitator appeared in 1937, a form of which is known as the Precipitron. In this device the function of ionization and precipitation is divorced.

The air is made to pass first between an ionizing space and then through a precipitating space. In the ionizing space a $7^1/_4$-mil tungsten wire is placed between parallel tubes. The negative terminal of a 13,000-volt d-c supply provided by a power pack is connected to the ionizing wire. The combined use of a lower voltage and positive potential to the ionizing wire results in the production of a negligible amount of toxic gases which thus permits the use of this system for ventilation and air conditioning. In passing through the ionizing space the dust particles collect positive charges which in passing through the precipitating zone cause the particles to be deposited on the negative plates. A source of 6,000 volts direct current, again supplied by a power pack, is used for the precipitating function. The resolution of the two functions by the two-stage precipitator permits utilization of the most efficient voltages for the respective purposes. Figure 5 shows on the right-hand side the charging unit and on the left-hand side a collecting unit. The air flow is from right to left in this figure.

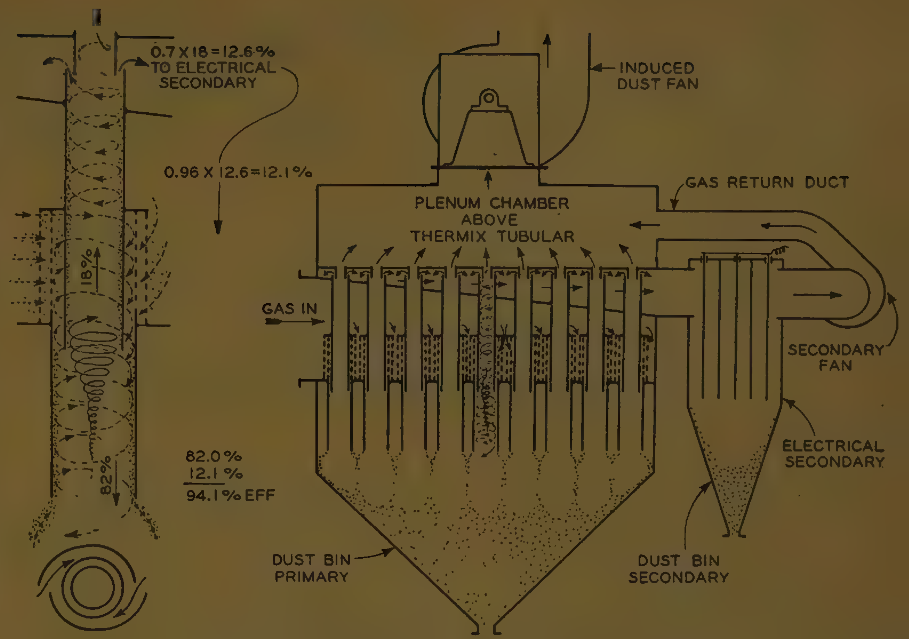



**Figure 6. Schematic diagram of duplex collector**

### APPLICATIONS OF THE PRECIPITRON

The Precipitron has many diversified applications in the domestic, commercial, industrial and central-station fields. The domestic and commercial applications have been of necessity curtailed during the war but the industrial applications have been expanding rapidly. A pilot application in central-station fields is in operation and will provide operating experience valuable to expansion after the war.

The domestic field is one of the most promising. Plans are underway to provide air cleaning for homes. The results obtained from installations in homes in the Pittsburgh area have been very gratifying particularly with regard to maintenance of household furnishings and as a boon to those suffering from hay fever. While the consumption of a particular unit is not large, in the aggregate the load is well worth while particularly as the load factor is excellent. A single unit will add an annual power consumption of about 300 kilowatt hours at 100 per cent load factor. As the present average home power consumption is about 1,000 kilowatt-hours per year, this represents an increase of 30 per cent.

The central-station engineers are interested in this device as a potential load builder.

Many interesting applications of the Precipitron in the industrial field during the war have been recorded. In some plants the oil mist produced by high-speed grinders became so serious that the condensate dripped from the walls and pipes. This led to premature electrical insulation failures and was a health and fire hazard. Precipitating the oil mist at its source not only eliminates this objection but also recovers the oil for reuse. Precipitrons also have been applied for cleaning the air for manufacture, assembly and inspection of aircraft engine parts, optical lenses and instruments, and many other precision products.

Another important application of the Precipitron is its use to clean the ventilating air of large rotating electric machines. A large number of installations have been made in the steel industry for cleaning the ventilating air for mill-drive motors, motor-generator sets and control rooms. Installations have also been made in the central-station field for synchronous condensers, switching rooms and general-purpose ventilation. Recently the Precipitron has been applied to clean the air in the closed recirculating systems of large d-c motors and generators. In this instance, the purpose is to collect the carbon dust borne from brushes to the commutator. The carbon dust is thus prevented from getting into the windings and this condition greatly extends the time between overhauls.

An application of great potentiality in the central-station field is the precipitation of fly ash in stacks. As a result of the researches of the Prat-Daniel Corporation and the Westinghouse Electric Corporation a duplex unit[1] consisting of a mechanical precipitator and an electrical precipitator has been developed. A pilot installation has been installed at the Huntley station of the Buffalo–Niagara Electric Corporation. This unit is intended to handle one quarter of the 900,000 pound per hour generating unit. The general arrangement of the duplex unit is shown on the right-hand side of Figure 6.

The general operation best can be expressed by considering in detail the functioning of a single unit of the mechanical collector which is shown on the left-hand side of Figure 6. The flue gas enters the periphery of the separator and is given a high rotative velocity or cyclonic effect. The heavier particles strike the wall of the tube and drop to the bottom of the primary dust bin. The flue gas then rises through the tube with a continued vortex action. The greater portion of the remaining dust is skimmed off through the upper annular slot to the electrical precipitator, the inner volume of the gas being carried off to the stack. Tests have shown that the efficiency of the Thermix tubular collector is about 80 per cent so that this portion of the dust content drops into the dust bin primary and the rest of the dust rises through the upper portion of the tube. If it is assumed that the collector at the top catches three quarters of the remaining dust then approximately 15 per cent of the original dust content is drained off to the electrical precipitator. The efficiency of the Precipitron for the smaller particles which still remain is in the order of 96 per cent. Thus, nearly all of the dust going to the Precipitron is collected in the dust bin secondary. The over-all efficiency of collection is thus approximately 95 per cent of the original dust content.

### MISCELLANEOUS

Many other applications might be cited; for example, the control of a d-c machine from an a-c source, various forms of lighting—the fluorescent lamp, the cathode-ray oscillograph, used to great advantage in impulse testing, and which has been responsible for the great advances in our knowledge of insulation coordination work, cable-testing outfits and a host of other interesting devices.

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# Statistical Methods in Quality Control

## IV. Subgrouping of Data—Finding Causes of Trouble

WHEN a manufacturing process is in trouble, the parts made in that process have variations in quality that go far beyond those normally expected and usually exceed the variations permitted in the engineering specifications. These unusual variations are of immediate importance so far as the manufacturing process is concerned—they often cause bottlenecks in production; they involve expense for rework, and they cause losses through scrap.

### FREQUENCY DISTRIBUTION

By plotting a frequency distribution of quality measurements, a picture of the present situation can be obtained at any time. But often the verdict of the frequency

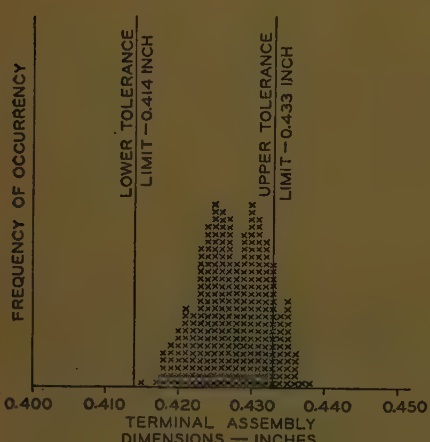


**Figure 1. Frequency distribution of 307 capacitor-cover measurements taken from all machines.**

distribution is that "something must be done to improve the process."

The frequency distribution shown in Figure 1 indicates the over-all terminal assembly dimensions as measured on 307 capacitor covers. On this job, the upper and lower engineering tolerance limits are 0.433 inches and 0.414 inches, respectively; these are indicated by vertical lines in Figure 1. The verdict of this particular frequency distribution is clear. Out of the 307 capacitor covers 29 had terminal assembly dimensions which exceeded the upper tolerance limit and thus 9.4 per cent of the covers were defective. Evidently, there is room for improvement in this process. The frequency distribution of 307 capacitor covers shows the extent of

**Analysis of raw materials, machines, and men as the three basic causes of variations in processing, and a recommendation for subgrouping of inspection and test data are given in this article.**

trouble, but does not answer the important question of "what kind of corrective action must be taken?" The manufacturing operations on these capacitor covers were performed by several different operators on several different machines. It is not known whether all operators and all machines are contributing to this trouble or whether it is "localized."

### CAUSES OF PROCESS VARIATIONS

One of the most effective ways of tracking down trouble comes through analysis

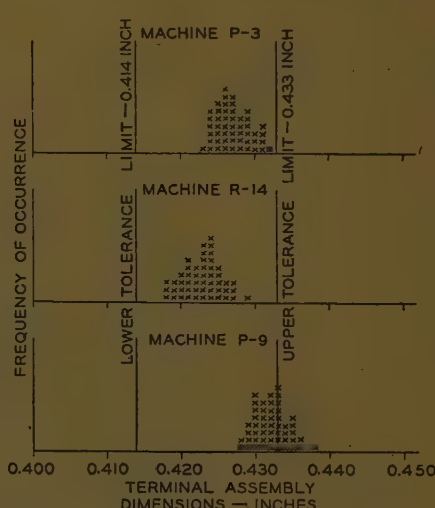


**Figure 2. Frequency distribution of capacitor-cover measurements taken from three different machines.**

of the effect of possible sources of unusual process variations. The three basic causes of variations in processing are raw materials, machines, and men. These causes may act independently or in unison as to their effect at given stages in production. To find out whether materials, machines, or men are causing the immediate process trouble, we must break down our data into subgroups.

On the capacitor covers, materials were found to come from a common source and to be of controlled quality. The remaining effect of machines and operators was a composite one and, therefore, had to be studied as a whole. As a first step, 50 covers were taken from each machine and plotted against the tolerance limits in the form of frequency distributions. Figure 2 shows typical frequency distributions from three different machines.

Each of these machines has a fairly narrow range for the spread of 50 measurements, but the average dimensions are greatly different. Machines *P*-3 and *R*-14 are making 100 per cent good parts; on the other hand, 24 per cent of the covers produced on machine *P*-9 are defective. Analysis of these subgroups seems to indicate that the machines are in good shape and that operators are doing good work,

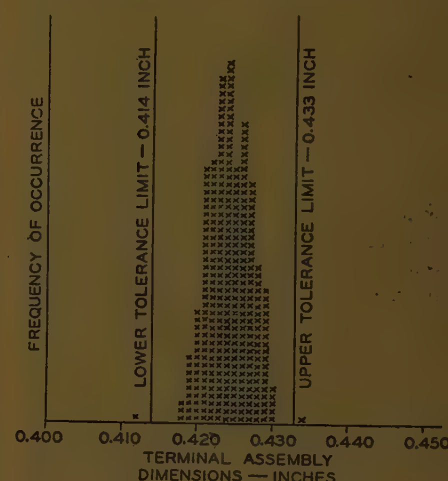


**Figure 3. Frequency distribution of 342 capacitor-cover measurements taken from all machines.**

but that the differences between machines as to quality are due either to setup or to drift of the dimension during machine use. This called for another study.

### RESULTS OF CHECKING

By taking successive checks on the same machine, it was found that:

(1) A given machine will operate at the setup dimension for a fairly long period.

(2) Substantial differences exist between the machines immediately after setup.

This later investigation clearly indicated that the setups were the principal cause of trouble. Action was taken. The nominal dimension of 0.424 inch was selected as a goal for each setup; the setup men were instructed to work as closely as possible to the nominal dimension.

Results showed up immediately in the form of closer adherence of individual covers to the drawing specifications. The overall-spread of measurements decreased as shown in Figure 3. The average measurement for 342 covers in this set was close

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Personnel of the AIEE subcommittee on educational activities: J. Manuele, H. F. Dodge, A. I. Peterson, and R. E. Wareham.

to the nominal of 0.424 inch and only two pieces fell outside tolerance limits.

Rational subgrouping of inspection and test data to show possible causes of trouble in processing is well worth while. Often, it gives a direct clue as to the real source of trouble; on other occasions, it shows that one variable or another is not the cause of trouble. Rational subgrouping should be the first step in tracking down and locating trouble existing in a manufacturing process.


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# Silent Electric Signaling and Control

A new design of mercury switch in which the tube containing the mercury does not move and the make-and-break action is magnetically controlled, has been developed by the Sordoviso Switchgear, Ltd., London, England, according to information supplied by A. G. Whyte through the British Information Service, New York, N. Y.

Earlier designs of mercury switch depended upon the tilting of a tube for the make-and-break action.

This appliance is a glass container with three electrodes, one at the top, one at the bottom, and the third at the side. Mercury partly fills the tube and on it floats an iron armature containing a ball which acts as a valve. When the switch is in the normal position the mercury flows freely into the armature and closes the circuit between the top and bottom electrodes. When, however, the armature is drawn down by the magnetic attraction of an external solenoid, the ball valve closes and the mercury, being thus prevented from flowing into the armature, is forced upwards outside the armature and makes contact with the electrode at the side. As soon as the solenoid is de-energized the reverse action takes place and contact between the top and bottom electrodes is restored. As the tube is filled—apart from the mercury—with nonoxidizing gas, any arc formed at the contacts is quickly and effectively quenched. The electrodes are made of a special alloy with a coefficient of expansion which ensures perfect sealing where they pass through the glass of the tube, and the switches are carefully tested for long periods to ensure no gas leakage.

A time element is introduced by providing in the armature a slot which acts as a by-pass when the ball valve is closed. With the armature in the down position the mercury outside it percolates slowly throught the slot, and eventually makes contact with the top electrode even though the solenoid is in action and keeps the armature down. By the same action the contact with the side electrode may be either broken or may remain closed according to the amount of mercury in the switch. The time interval can be regulated within close limits by adjusting the size of the slot. An important detail of this type of automatic switch is that the movement of the valve keeps the slot clean, so that the mercury always flows freely.

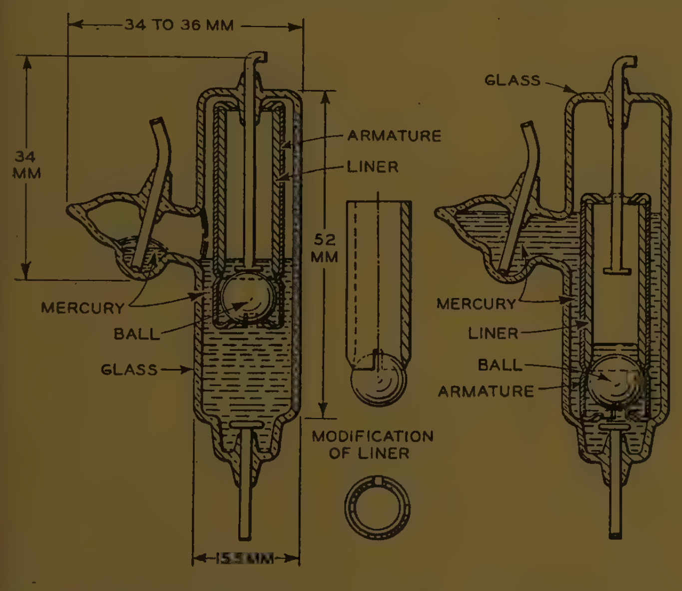


**Diagram of the internal mechanism of the Sordoviso mercury switch**

One of the numerous applications of this device is the provision of light signals in place of bells. In houses the ordinary electric bell or buzzer may not be heard in all the rooms, and in small houses the sound may cause confusion by being audible to neighbors. The Sordoviso switch affords a simple means of associating the bell circuits with the light circuits so that when the bell push is pressed, the lights, if in operation, are dimmed and, if not in use, are switched on. Thus a silent, light signal takes the place of the sound. To effect this purpose the switch is incorporated with a relay, the solenoid of which is connected in series or in parallel with the bell; while the mercury switch is connected in series with one of the leads from the lighting mains through a four-way rotary switch, which enables adjustment for day, night, and for other conditions to be made. The switching on or the dimming of the lights does not last for more than a second or two, owing to the time-control feature just described, but the signal is positive and unmistakable. The equipment is easily installed; does not interfere with existing wiring, and can be adapted to meet many requirements. In the Sordoviso staff-locating system a number of colored or numbered lights are used; by combinations of these as many as 50 different calls are possible. From a transmitting post to the receiving posts where the lights are installed only two wires of the type used for bells are required.

Relays and contactors fitted with these switches provide a flexible and efficient means of controlling electrical circuits. Standard units are capable of controlling double, triple, and multiple pole circuits up to 24 separate circuits. Here the small energizing current required is an important feature and the adoption of delayed action enables the respective circuits to be opened and closed after a predetermined interval or in a given sequence; the period of delay may be varied from one quarter of a second to five minutes. Similar equipment is adapted to the control of street lighting systems, where the time-delay action is useful in securing a gradual process of switching on, section by section. Flashing signs can be controlled likewise, the rate ranging from 90 to 180 flashes per minute. In many of these applications the immunity of the switch against humidity, acid fumes, and the action of the atmosphere in general is an important feature.

# INSTITUTE ACTIVITIES

## Fall Technical-Paper Program Announced—Discussion Closes October 15

Due to travel restrictions and the cancellation of meetings, the third series of technical papers to replace that which normally would have been presented at the Pacific Coast technical meeting, is offered for discussion by mail.

The program features a variety of subjects and two important symposiums, one on high-frequency cables, the other on central-station auxiliaries.

The symposium on high-frequency cables consists of 17 contributions and four summaries of discussions by authors who have taken a prominent part in the theory, development, and manufacture of high-frequency cables. This development has grown almost into an industry within itself and represents one of the important contributions to World War II in the field of communication. The symposium is presented in a report of the conference on high-frequency cables sponsored by the AIEE committee on communication with the co-operation of the Army-Navy Radio-Frequency Cable Co-ordinating Committee, Lieutenant Commander John H. Neher, chairman.

The symposium on central-station auxiliaries is arranged to present an up-to-date cross section of the existing practices as well as present trends in the design of systems and equipment. The points of view of operating companies and large electrical manufacturers will be brought out in several papers and such aspects of the subject as reliability, space factor, "unit-type" station design, types of electric drives, and degrees of protection will be considered. The symposium like the one on high-frequency cables is the outgrowth of a conference held during the winter meeting and it is sponsored by the AIEE committee on power generation.

In addition, other papers will be offered in the fields of air transportation, applications of statistical methods, communication, basic sciences, power generation, power transmission and distribution, protective devices, industrial power applications, capacitors for induction and high-frequency heating, and electric machinery.

Pamphlet copies of papers, for which abstracts appear in the section immediately following, may be ordered, at prices shown, from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. Coupon books in five-dollar denominations are available. An order form is included with the announcement of the program that is being mailed to members in the United States and Canada.

If you have had experience along the lines of the subject matter in any of the papers, help advance the profession by submitting your remarks in writing. Discussion should be mailed in triplicate before the closing date of October 15, 1945, to C. S. Rich, secretary of the technical-program committee, AIEE, 33 West 39th Street, New York 18, N. Y. The papers and approved discussion ultimately will be published in AIEE *Transactions;* most of the papers also will appear in *Electrical Engineering.*

## ABSTRACTS • • • •

### Air Transportation

**45-154—Instability in D-C Aircraft Systems;** *H. B. Bunce (A '43), J. C. Cunningham (A '42), W. M. Davidson (A '42). 20 cents.* A laboratory and theoretical study was made to determine the causes and methods of combating an unstable oscillatory-voltage condition which has been encountered in aircraft d-c electric systems using types *P*-1, *P*-2, and *R*-1 generators with carbon-pile voltage regulators. The generator characteristics were found to be such that oscillatory instability would not occur without the presence of a voltage regulator which was out of adjustment and which had inadequate damping. A method is given for determining the amount of damping required for stable operation in terms of the generator-field time constant and certain regulator characteristics.

—VICTORY—

*Electrical Engineering* unites with all the members of AIEE in rejoicing over the conquest of evil by the forces of democracy and right. To the members who served their country abroad or at home—either in active combat or in some other capacity, it extends its congratulations and thanks for their prodigious efforts resulting in achievements which long after the "days of our years" will redound to the benefit of peoples everywhere.

* * *

In this new era of peace and progress *Electrical Engineering* carries on as it has in the past—reporting and reviewing all advances in electrical engineering—but with a more definitive responsibility in anticipating or in announcing the improved implements of science.

—PEACE—

**45-158—Parallel Operation of Main-Engine-Driven 400-Cycle Aircraft Generators;** *L. G. Levoy, Jr. (M '43). 20 cents.* This paper reports progress in the development and testing of variable-ratio drives and governors for parallel operation of aircraft alternators driven from the main engines. Preliminary tests have been made demonstrating successful parallel operation of such drives under various conditions of acceleration and loading. The general system of operation and results of some of the first tests are described in this paper. The conclusion is reached that the operation of 400-cycle a-c alternators for the supply of auxiliary power in large aircraft, driven from the main engines through variable-ratio drives, is feasible and parallel operation of these alternators is practical.

**45-161—The Electrical Resistivity of Resin-Treated Wood and Laminated Hydrolyzed-Wood and Paper Base Plastics;** *R. C. Weatherwax and A. J. Stamm. 20 cents.* The volume electrical resistivity of 10 species of wood, impreg and compreg made therefrom, and laminated paper and hydrolyzed-wood plastics were determined in the partially oven-dry condition and in equilibrium with four different relative humidities ranging from 30 to 90 per cent. Impreg gave the highest resistivities and normal wood the lowest. At 30 per cent relative humidity the resistivity of impreg is more than 10 times that of normal wood while at 90 per cent relative humidity it is almost 1,000 times that for normal wood. These measurements, together with measurements of the electrical resistance by the American Society of Testing Materials method, indicate that impreg, compreg, hydrolyzed-wood plastic, and laminated-paper plastic made with relatively electrolyte-free phenolic resins are suitable for electrical insulating purposes.

**45-163—Constant-Speed Drives for Aircraft Alternators;** *C. J. Breitwieser (M '44). 20 cents.* As the electric-power-system demands and physical size of airplanes have grown in recent years, it has been necessary to develop new electric systems for large aircraft. Most of the new, large airplanes will use 208/120-volt-phase 400-cycle a-c systems. One of the main problems of this new system has been the development of a constant-speed drive to couple the alternators to the main engines of the airplane. This paper discusses this problem, and describes several types of constant-speed drives. The salient features of finite-ratio gear systems, infinite-ratio mechanical couplings, and hydraulic couplings are outlined, and their kinematics briefly described.

**45-165—Resonant-Circuit Constant-Current Regulators;** *G. M. Kevern (A '40). 15 cents.* Airport approach and runway marker light circuits are quite similar to the usual street-lighting circuits, except that the important additional feature of brightness control is required. Standard moving-coil

regulators were found to be unsatisfactory for this purpose, so the development of resonant-circuit constant-current regulators with built-in brightness control was fostered by the Army Air Forces. Four years of service have proved regulators of this type to be entirely satisfactory, and they have been adopted as standard by the Army, Navy, and Civil Aeronautics Administration. Resonant-circuit regulators have no moving parts, and operate at high efficiencies and power factors, even at light loads. Detailed performance data, together with a comparison of resonant-circuit and moving-coil regulators, are presented.

## Basic Sciences

**45-159—The Self-Inductance of a Toroidal Coil Without Iron;** *H. B. Dwight* (*F' 26*). *15 cents.* If a nonmagnetic bar is bent to form a ring and a single layer of wire is wound around it, the self-inductance of the toroidal coil so formed is given by well-known short expressions. In this paper is given a computation for the inductance of a toroidal coil of rectangular section and thick winding. The magnetic flux passes through the rectangle around which the wire is wound and through four parts of the cross section of the winding, each part having the shape of a trapezoid. A separate algebraic formula is derived for the flux linkages of each part, except that the two parts at the ends of the coil are alike. The computation is believed to have good accuracy for usual cases, but it is not so precise as most inductance computations for cylindrical coils. A numerical example of a 3,000-turn coil is given.

## Communication

**45-145—Report of Conference on Radio-Frequency Cables;** *AIEE committee on communication.* *65 cents.* The development of solid dielectric radio-frequency cables was the subject of a conference sponsored by the committee on communication and the Army–Navy Radio-Frequency Co-ordinating Committee at the AIEE 1945 winter technical meeting. Prominent engineers of the Government and of many industrial companies who have taken an active part in this development presented papers and participated in the discussion. This is a compilation of the papers and the discussion and covers from a broad viewpoint: "The Development of Radio-Frequency Cables in the United States," "The General Characteristics of Polyethylene," "Polyethylene as a Cable Insulation," "Dielectric Strength of Polyethylene," "Properties of Different Polyethylenes," "Radio-Frequency-Cable Manufacturing Methods," "General Consideration of Radio-Frequency-Cable Design," "Losses in Radio-Frequency-Cable Components," "Radio-Frequency-Cable Power Ratings and Stability," "Types of Cables and Specifications," "Shielding Characteristics of Radio-Frequency Cables," "Design Considerations of High-Frequency Twin-Conductor Cables," "Methods of Electrical and Mechanical Testing of Radio-Frequency Cables at the Naval Research Laboratory," "Electrical Tests Over a Range of Frequencies," "The S-Function Method of Measuring Attenuation of Coaxial Radio-Frequency Cable," "Corona Initiation Measurements of Polyethylene and Rubber Cables," and "A Corona Voltmeter."

**45-146—A Study of Wave Shapes for Radio-Noise-Meter Calibrations;** *C. W. Frick* (*A '19*). *30 cents.* It is shown through experiment and calculation that the radio-noise meters now available are used to better advantage as to accuracy and intercomparison of results when calibrated on a square wave instead of the commonly used sine-wave signal generators. Wave generators of different designs are analyzed and compared as to suitability for calibration purposes. Tests are described wherein both the present and the proposed calibration methods are employed. Noise meters built to present accepted specifications checked reasonably well with either calibration method. However, when a noise meter and a receiver setup were calibrated on sine waves, differences as much as three to one were found. The square-wave calibration materially reduces such differences, in these tests to an average of 15-per-cent difference between instruments including the receiver. It is concluded that suitable generators can be built which are stable and can be used as standards for noise-meter calibrations.

**45-149—Optimum Air Gap for Various Magnetic Materials in Cores of Coils Subject to Superposed Direct Current;** *V. E. Legg* (*M '37*). *20 cents.* The design of coils used as chokes in a-c circuits which must also carry direct current is complicated by the reaction of the air gap on the distribution of a-c and d-c magnetomotive forces between core and airgap. Consideration has been given to the general problem of adjusting the size of magnetic core, air-gap length, and number of turns in the winding of a coil to fulfill specifications as to inductance, resistance, and d-c carrying capacity. The mathematical means have been worked out for fulfilling specified conditions with a minimum quantity of core materials whose permeability and reversible-permeability curves are given. Calculations have been made for several typical materials to illustrate the method of utilizing this type of analysis.

**45-155—Judging Mica Quality Electrically;** *K. G. Coutlee.* *25 cents.* A threatened mica shortage, resulting from an unprecedented wartime demand for mica capacitors used in electronic communication equipment by the Armed Forces, was forestalled by rigid conservation measures, use of alternate materials, and the use of electrically selected mica from types previously considered unsuitable for capacitor use. By employing two electrical tests in combination with visual and physical requirements, mica was selected from plentiful stocks of visually lower quality types of mica, which effectively increased the supply of capacitor mica by 60 per cent. This method of electrically judging the quality of raw mica was given a thorough commercial trial and found both practicable and reliable.

## Electric Machinery

**45-143—Per-Unit Impedances of Synchronous Machines—II;** *A. W. Rankin* (*A '38*). *15 cents.* Part I of this paper presented generalized formulas for the per-unit impedances of synchronous machines and showed that those internal machine impedances which cannot be measured from the stator terminals are subject to misinterpretation and misuse unless the rotor-current bases on which they have been calculated are explicitly defined. Part II brings together and evaluates the four major rotor-current bases which are in use in contemporary literature and illustrates quantitatively the magnitude of the possible errors involved in the misapplication of per-unit impedances calculated on a rotor-current base not explicitly defined. One specific base current is defined and evaluated, and its adoption as a preferred base is suggested. Standardization on one base-current ratio for all per-unit impedance calculations would make the published formulas more widely applicable and would tend to eliminate errors due to any inadvertent change of rotor-current base in the calculation of the various impedances.

**45-156—Dielectric Strength and Protection of Modern Dry-Type Air-Cooled Transformers;** *P. L. Bellaschi* (*F '40*), *Edward Beck* (*M '35*). *15 cents.* The wide acceptance of the dry-type transformer in industry naturally has increased interest in its application and standardization. In this paper impulse levels and methods of protection for this type of apparatus are presented and discussed. Applications are classified conveniently as unexposed, quasi-exposed, exposed, and highly exposed. Until recently the principal application has been to circuits unexposed to lightning, for which in general no surge protection is required. This recommendation likewise holds for quasi-exposed circuits, that is, where there are intervening oil-immersed transformers between the dry-type transformer and a highly exposed circuit, provided the former are properly protected on the exposed side. On highly exposed circuits protective devices are recommended on the incoming lines, preferably 500 to 1,000 feet from the transformer, in addition to low-ratio arresters at the transformer terminals. The low-ratio arresters are the types developed for the protection of rotating machines. Where the exposure is not severe, protective devices on the line may be omitted. Actual tests are presented which bear out the basis and reasons for these recommendations.

**45-162—Fundamentals of the Amplidyne Generator;** *J. L. Bower* (*M '43*). *30 cents.* The author presents an analysis of the transient and steady-state response of the Amplidyne generator in operational form. Standard tests for the determination of Amplidyne characteristics are described, and are explained theoretically by reference to the analysis. The effects of hysteresis and eddy currents, and the very important commutation problem, receive attention in the discussion.

**45-166—Wound and Dummy Rotor Method of Quality Control and Trouble Shooting of Induction Motor Windings and Cores;** *P. H. Trickey* (*M '36*). *15 cents.* Two of the six constants which determine induction motor performance characteristics, $X_0$, open circuit reactance and $F_e$, iron loss may be investigated and controlled by two somewhat similar methods of testing. "Dummy" rotors made like a normal squirrel-cage rotor, but without the squirrel cage

may be used in very sensitive tests to determine small variations and defects in stators. "Wound" rotors, where the rotor winding produces the excitation for the flux, provide very sensitive tests for the permeance and iron loss of stator cores. They also make very useful turn counters. For investigation and research, normal frequency gives readings in the same order as in normal operation. For particularly sensitive testing, high frequency such as 500 or 1,000 cycles is often used. Armatures from repulsion motors and d-c motors will often make emergency test rotors for such tests.

## Induction and Dielectric Heating

**45-157—Capacitors for High-Frequency Induction-Heating Circuits;** *F. M. Clark (A '24), M. E. Scoville (M '41). 20 cents.* Increased military production has accelerated the application of high-frequency heating where accurate control of temperature for short intervals is fundamentally important. The heating of metals by induction has been widely applied. The present paper describes the development of a new type of dielectric liquid called Lectronol. Capacitors containing this liquid are particularly well adapted for use in the tank circuit of electronic heaters used in induction heating. The capacitor is water cooled and is housed in a hermetically sealed completely filled nonmagnetic container so constructed as to provide sufficient flexibility to take care of the liquid expansion due to thermal changes. The capacitor is noteworthy because of the absence of cellulose sheet insulation, satisfactory operation being entirely dependent on the superior insulating properties of the Lectronol. Capacitors containing this liquid are characterized by low dielectric loss and high dielectric strength over the frequency range utilized in power oscillators. The capacity per unit volume is approximately twice that obtained with mineral oil. The electrical characteristics of the capacitor are stable under severe conditions of use.

## Industrial Power Applications

**45-140—Electric Power in a Steel Plant;** *R. W. Graham (M '31). 15 cents.* This paper gives a brief summary of the various uses of electricity in a steel plant with a description of the power system necessary to supply the various equipment. This is followed by a description of the relay installation on the transmission system for sectionalizing system faults and machine protection.

**45-164—Maintenance of Good Brush Performance;** *W. C. Kalb (F '40). 20 cents.* There are certain criteria by which the performance of brushes in respect to their three major functions should be judged. Successful performance of these functions necessitates care in the preparation and maintenance of the commutator or slip ring surface, and in the installation of the brushes on the machine. The nature of the commutator surface film has a marked influence on brush performance, and there are numerous factors affecting its development and maintenance. The trend of design toward higher commutator speed gives increasing importance to those factors which affect the intimacy of contact between brushes and commutator. Systematic analysis of observed indications of unsatisfactory operation simplifies identification of the primary fault and restoration of good brush performance.

## Power Generation

**45-139—Control of Load, Frequency, and Time of Interconnected Systems;** *C. K. Duff (M '41). 25 cents.* The general problem is stated and typical solutions indicated. Characteristics of governors and of frequency- and load-control devices are explained briefly, and effects on generator and tie-line loads are summarized. To illustrate the principles enunciated, interconnected systems in southern Ontario and adjacent portions of Quebec, totaling 1,650,000-kw generating capacity are described, as well as operating experience with automatic frequency control and automatic load control of two ties, one of which is a 45,000-kw frequency-changer set interconnecting systems of relatively large capacity.

**45-150—Power Systems for Auxiliary Drives in Steam-Electric Stations;** *J. B. McClure (A '29), S. I. Whittlesey (A '45). 25 cents.* The general use of a-c motor-driven auxiliaries in steam-electric stations, together with the increased acceptance of factory-assembled equipment for power distribution, now makes it opportune to discuss the design of the power system for these auxiliaries. As a result of discussions with several operating groups, and after studying various types of auxiliary power systems, the following general conclusions, which should serve as a guide in planning power systems for auxiliaries, have been reached: a separate auxiliary power system should be considered for each boiler; power supply from the main generator leads is being increasingly used; the preferred voltages are 460 and 2,400 volts; it is economical to use a single-voltage 460-volt system where the required transformer capacity per boiler does not exceed 1,000 kva; a dual-voltage system comprising 2,400 and 460 volts should be considered where the required transformer capacity per boiler is 1,500 kva or greater; and in a dual-voltage system motors up to at least 250 horsepower can be applied economically to 460 volts. In addition the paper gives estimating data for auxiliary power requirements which will permit preliminary system designs. There also are included several suggested system arrangements; ratings and features of available equipment for this type of service; and tables which will simplify the proper applications of these equipments.

**45-151—Electric Drives for Steam-Electric Generating-Station Auxiliaries;** *W. R. Brownlee (M '38), J. A. Elzi (M '38). 15 cents.* The exclusive use of electric drives for all auxiliaries in modern steam-electric generating stations has a background of several years of successful operation on a number of power-supply systems and has shown gratifying over-all reliability and economy. As brought out by this paper, these results have been achieved through co-ordinated design backed by extensive tests. The basic requirements of the auxiliary drives are analyzed, together with the motor applications to co-ordinate with them. Thorough consideration has been given to the vital question of power supply for the auxiliaries, and definite conclusions are given as to the scheme which provides the desired objectives. No small part of the successful performance of the all-electric drive depends on the correct application of motor control and protection. The test results which have been included demonstrate the satisfactory performance that can be secured from the co-ordinated all-electric design during the most severe operating conditions and provide useful information for future designs.

**45-152—Auxiliary Power Supply for Generating Stations;** *V. E. McCallum (M '38). 15 cents.* All recent electric generating stations have been built with a major portion of their auxiliaries driven by motors, and the present station is dependent at all times on the integrity of the auxiliary power system; therefore, this system must be designed for maximum reliability. Where the electric station is a part of an interconnected system and the station busses are segregated and relayed for fault protection, it is suggested that the station generator busses are the most reliable source of power and that a separate and independent auxiliary power service unit be provided to serve the maximum amount of generating capacity, the loss of which could be sustained by the system without undue disturbance.

**45-153—Central-Station Auxiliary-Drive Motors for Constant and Adjustable Speed;** *Hal Gibson (A '44). 15 cents.* Central-station auxiliary drives must be selected with the object of obtaining maximum reliability. This paper reviews the general recommendations for these motors from the standpoint of type, enclosures, insulation, bearings, adjustable speed motors, and high-speed gears and motors. The stability of a wound-rotor induction motor with secondary control below 50 per cent of rated speed also is discussed briefly, as is power savings for fan drives with wound-rotor and two-speed motors over constant-speed motors and throttling dampers.

## Power Transmission and Distribution

**45-141—The Frequency of Occurrence and the Distribution of Lightning Flashes to Transmission Lines;** *R. H. Golde (A '42). 30 cents.* From physical principles a method has been developed of calculating the protection afforded by a lightning conductor or similar structure. The protective range is found to vary with the amplitude of the lightning current. The numerical results derived are applied to a calculation of the distribution of direct strokes between towers and phase wires of a transmission line, the increase in the number of strokes due to the installation of earth wires, and the distribution of strokes to towers and earth wires in the latter case. The frequency of flashes to earth over a given area is shown to be related to the isokeraunic level of the district involved. Numerical results obtained for the aforementioned problems are compared with field observations.

**45-144—Sag and Tension Calculations for Cable and Wire Spans Using Catenary Formulas;** *J. F. Nash (M '26), J. F. Nash, Jr. 25 cents.* This paper develops a new method for solving sag and tension problems for wire and cable spans. This mathematically exact procedure, though derived entirely from catenary formulas and derivations thereof, uses working formulas requiring only simple arithmetical calculations which can be handled by engineering-office clerical personnel. Laborious calculations and trial-and-error computations necessary with other methods are eliminated. This method develops not only sags, tensions, and cable lengths for the various final and initial conditions of the design span but also similar data for other length spans related to the design span. The method also outlines a new exact method for sag and tension calculations for hillside spans and previously unpublished relationships between sags, tension, and cable lengths.

**45-160—Costs Study of 69- to 230-Kv Underground Power-Transmission Systems and Tie Lines;** *J. G. Holm (M '29). 30 cents.* Thirty underground power-transmission systems and tie lines have been designed and their capital and annual costs determined. The 69-kv lines have solid and oil-filled cables, and the 138-kv and 230-kv lines have oil-filled cables. Systems have ratings from 50,000 to 600,000 kva. Power is transmitted at distances of ten and 15 miles over one to four circuits. System costs are those immediately preceding the current war; they are based on data obtained from manufacturers, as well as on actual construction data. The results give an economic zone of application of various cables. They show that there is an economic relationship between the transmission voltage and the block of power transmitted. Curves are given from which costs of various underground systems or their parts may be estimated at prices similar to or different from those taken in the study. The optimum system rating and voltage most suitable for certain conditions may be determined from the data given.

## Protective Devices

**45-147—Lightning Arresters for Distribution Apparatus;** *Edward Beck (M '35), A. D. Forbes (M '42). 20 cents.* The major item on distribution systems that requires lightning protection is the distribution transformer. Protection is an integral part of the completely self-protected transformer. When lightning arresters are installed separately, two general types are used, the expulsion and the valve types. Their differences in operating characteristics and mechanical construction are discussed. The protective characteristics of the arresters are compared with the impulse withstand tests for distribution transformers.

**45-148—Phase-Comparison Carrier-Current Relaying;** *A. J. McConnell (A '36), T. A. Cramer (A '41), H. T. Seeley (A '27). 30 cents.* This paper describes a carrier-current differential-relaying system which operates to trip both terminals of a faulted line section simultaneously when fault currents are greater than predetermined limits. All application limits are given in a section outlining application procedure. The system employs a single carrier-current channel. Therefore, a single quantity for transmission and comparison must be derived from phase-fault and ground-fault currents. Reasons for the choice of the components of the single quantity are developed by analysis of the requirements of the various types of faults. The result is an overcurrent relaying system which

1. Does not require current in excess of maximum full-load current, except during three-phase faults.

2. Does not depend upon the operation of any relay for the transmission of the carrier-current blocking signal, except during three-phase faults.

The various relay components are described, and the characteristics of these components and of the over-all system are given.

## Lamme Medal Nominations

Attention is called again to the opportunity open to any Institute member to submit nominations for the 1945 AIEE Lamme Medal. All nominations must be received not later than December 1. For particulars see *Electrical Engineering*, June 1945, page 227.

The 1944 medal was awarded to S. H. Mortensen, chief electrical engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. An account of the presentation of the medal to him was published in the August *Electrical Engineering*, page 300.

## AIEE Member in the News

Among those who worked to perfect the powerful atomic bomb, the news of the first application of which stunned the world on August 7, 1945, is Doctor Vannevar Bush (A '15, F '24) director of the Office of Scientific Research and Development. His recent report to the President, "Science the Endless Frontier," which recommends a program for postwar scientific research is referred to elsewhere in this issue. Doctor Bush was one of the scientists who "stood by" in the trial of the first man-made atomic explosion set off July 16 at the Alamogordo Air Base in the New Mexico desert and saw the steel tower, atop of which the bomb was hauled on July 14, vaporized, leaving only a huge sloping crater.

A few technical details of the atom bomb released by the Army will be published in a forthcoming issue.

## AIEE Board of Directors Meeting

The regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, N. Y., June 27, 1945.

Petitions were presented for the election of Doctor Gano Dunn and Doctor Frank B. Jewett as Honorary Members, and members of the board present voted unanimously for their election. Affirmative votes were received from all absentees.

The finance committee reported, and the board approved, expenditures in June amounting to $33,454.03, which included payment for the 1945 *Year Book.*

An appropriation of $152 was made as the Institute's share of an expense to be incurred by the joint committee to study the organization of the engineering profession, in the preparation by Engineers' Council for Professional Development of a classified list of engineering societies.

The formation of a Beaumont Section was authorized, upon recommendation of the Sections committee, with territory in the following Texas counties: Jefferson, Orange, Hardin, Polk, Sabine, Tyler, Jasper, Shelby, Newton, Trinity, San Augustine, Angelina, and Nacogdoches.

Recommendations of the Standards committee for the appointment of the following AIEE representatives were approved:

L. C. Larson to Sectional Committee C70 (Domestic Electric Flatirons) and Sectional Committee C71 (Household Electric Ranges), to replace R. E. Johnson, resigned.

F. P. Kuhl to Sectional Committee Z14 (Drawings and Drafting Room Practice), to replace H. W. Samson, resigned.

G. S. Lunge to Sectional Committee Z32 (Graphical Symbols), to replace H. W. Samson, resigned.

S. B. Ingram to Sectional Committee C60 (Vacuum Tubes for Industrial Purposes), to replace M. J. Kelly, resigned.

A. C. Monteith to Sectional Committee C67 (Voltages Below 100), to replace C. A. Powel, resigned.

Upon recommendation of the Standards committee, the board approved a revision, prepared by the committee on marine applications, of AIEE Standard 45 "Recommended Practice for Electrical Installations on Shipboard," and approved for publication as a report of a proposed standard, proposed Standard for "Expulsion-Type Distribution Lightning Arresters," prepared by the committee on protective devices.

Final reports were received from various special committees and representatives.

Other matters were discussed, reference to which may be found in this or future issues of *Electrical Engineering.*

Other actions taken included the following:

Minutes of the meeting of the board of directors held May 29, 1945, were approved.

Recommendations adopted by the board of examiners at a meeting on June 14, 1945, were presented and approved. Upon recommendation of the board of examiners, the following actions were taken: seven applicants were transferred to the grade of Fellow; 45 applicants were transferred, and 39 were elected to the grade of Member; 221 applicants were elected to the grade of Associate, and 148 Students were enrolled.

Those present were:

*President*—Charles A. Powel, East Pittsburgh, Pa. *Past presidents*—N. E. Funk, Philadelphia, Pa., H. S. Osborne, New York, N. Y. *Vice-presidents*—L. A. Bingham, Boulder, Colo., C. B. Carpenter, Portland, Oreg., M. S Coover, Ames, Iowa, J. F. Fairman, New York, N. Y., W. J. Gilson, Toronto, Ont., R. T. Henry, Buffalo, N. Y., C. W. Ricker, New Orleans, La., R. W. Warner, Austin, Tex., W. E. Wickenden, Cleveland, Ohio. *Directors*—P. L. Alger, Schenectady, N. Y., K. L. Hansen, Milwaukee, Wis., C. M. Laffoon, East Pittsburgh, Pa., T. G. LeClair, Chicago, Ill., F. R. Maxwell, Jr., Pensacola, Fla., M. J. McHenry, Toronto, Ont., C. W. Mier, Dallas, Tex., S. H. Mortensen, Milwaukee, Wis., W. B. Morton, Philadelphia, Pa., D. A. Quarles, New York, N. Y. *Treasurer*—W. I. Slichter, New York, N. Y. *Secretary*—H. H. Henline, New York, N. Y.

Those present by invitation were:

*Incoming officers*—E. S. Fields, Cincinnati, Ohio; F. L. Lawton, Montreal, Que., J. R. North, Jackson, Mich., L. M. Robertson, Denver, Colo., H. B. Wolf, Charlotte, N. C.

# PERSONAL • • • •

**Frank Baldwin Jewett** (A '03, M '10, F '12) retired vice-president, American Telephone and Telegraph Company, New York, N. Y., and president of AIEE, 1922–23, was elected an Honorary Member of the Institute, June 27, 1945. Doctor Jewett was born at Pasadena, Calif., September 5, 1879. In 1898 he was graduated from Throop Polytechnic Institute (now the California Institute of Technology) with the degree of bachelor of arts. Following his graduation he engaged in graduate study in physics, mathematics and chemistry at the University of Chicago, and during his last year there he acted as research assistant of the department of physics, receiving the degree of doctor of philosophy in 1902. Doctor Jewett then went to the Massachusetts Institute of Technology, Cambridge, where he continued study and was instructor in physics and electrical engineering. In 1904 he entered the employ of the American Telephone and Telegraph Company and was shortly thereafter given charge of its engineering research work. From 1908–1912 he was transmission and protection engineer, responsible for the development of equipment. In the last-mentioned year he became assistant chief engineer of the Western Electric Company, New York, N. Y., and in 1916 was appointed chief engineer in charge of the research laboratories. Six years later he was promoted to vice-president. This position extended his duties to include the supervision of all the manufacturing operations of that company in America, together with the direction of the sales and distribution of its manufactured product. In addition he co-operated in the development of the vacuum tube, the telephone repeater, and the high-speed submarine telegraph cable, and the building of the transcontinental telephone lines. In 1917 he was commissioned a major in the Signal Corps, United States Army Reserves, and was later promoted to lieutenant-colonel in the Signal Corps of the regular army. For his service during the war, he received the distinguished service medal. In 1925 he became vice-president of the American Telephone and Telegraph Company, in direct charge of the department of development and research, and at the same time was elected president and a member of the board of directors of the Bell Telephone Laboratories, Inc., conducting the laboratory and research work, and in 1940 he became chairman of the board of directors. Doctor Jewett retired from the American Telephone and Telegraph Company in 1944. In that year he was awarded the doctor-of-science degree by Boston University, and the doctor-of-laws degree by Norwich University. In his honor in September 1944 the Frank B. Jewett Fellowships were inaugurated by the American Telephone and Telegraph Company. These fellowships provide for the full-time continuation of academic research. His contributions to AIEE affairs are outstanding. In addition to being president, he was manager 1915–1918 and vice-president 1918–1919 and has represented the Institute on the Engineering Foundation Board, the National Research Council, the John Fritz Medal Board of Award, the Hoover Medal Board of Award, the American Engineering Council, and the Iwadare Foundation. Among the many AIEE committees on which he has served are those on: the Edison Medal, executive, law, protective devices, research, Standards, telegraphy and telephony, education, co-ordination of Institute activities, and the code of principles of professional conduct. His scientific attainments have been recognized by the additional honorary degrees of doctor of science, New York University and Dartmouth in 1925, from Columbia University and the University of Wisconsin in 1927, and from Rutgers University in 1928; by the honorary degree of doctor of engineering from the Case School of Applied Science in 1928; and the Fourth Order of the Rising Sun, which was bestowed upon him by the Japanese Government. Doctor Jewett has been the recipient of the Edison Medal, Faraday Medal, Franklin Medal, and John Fritz Medal. He was elected president of the National Academy of Sciences in 1939, and re-elected in 1943. He has been active in The Engineering Foundation, and in the National Research Council.

**F. B. Jewett**

**C. F. Kettering** (A '04, F '14) vice-president in charge of research, General Motors Corporation, Dayton, Ohio, will direct a new Cancer Research Institute, in New York, N. Y., a $4,000,000 fund for which Alfred P. Sloan, Jr., chairman of the corporation, has recently granted. Doctor Kettering, who will concentrate on the organization of industrial techniques for cancer research, was born at Loudonville, Ohio, and was graduated from the course in electrical engineering at Ohio State University in 1904. He has been the recipient of the honorary degree of doctor of engineering and doctor of science from several universities, and many other honors have been conferred on him. Early in his career he was associated with the Star Telephone Company, Ashland, Ohio and later with the National Cash Register Company he developed the electrically driven cash register. In 1916 he established a research laboratory at Dayton which was taken over by the General Motors Corporation in 1920, and it was moved to Detroit in 1925. Doctor Kettering was elected to receive the Washington Award of the AIEE in 1936 and was awarded the John Fritz Medal for 1944 "for notable accomplishments in the field of industrial research which have contributed greatly to the welfare of mankind and of the nation."

**Gano Dunn** (A '91, M '94, F '12) president of the J. G. White Engineering Corporation, New York, N. Y., for more than 30 years was elected an Honorary Member of the Institute, June 27, 1945. Mr. Dunn was born in New York, N. Y., and received the bachelor-of-science degree from the College of the City of New York in 1889, the degree of electrical engineer from Columbia University in 1891, and master-of-science degree from the former college in 1897. During the period of 1886 to 1891 he worked for the Western Union Telegraph Company as a night telegraph operator, and in 1891 accepted a position with the Crocker-Wheeler Company. His promotion with that company was rapid and he became its vice-president and chief engineer in 1911. In that same year he was offered a vice-presidency of J. G. White and Company. He assisted Mr. White in organizing the J. G. White Engineering Corporation and three years later became its first president. During World War I the J. G. White Engineering Corporation built many important government projects, such as the great steam plant at Muscle Shoals, nitrate plants, and government aviation terminals. Mr. Dunn has taken an active part in the management of the AIEE. He has served on its governing board as a manager and vice-president, and during 1911–12 he was its president. He has also served on many committees of AIEE and other societies which include among them the following: code of principles of professional conduct; iron and steel industry; public policy; John Fritz board of award; licensing of engineers; education; American Association for the Advancement of Science, and the board of trustees, United Engineering Societies. From 1923 to 1928 Mr. Dunn was chairman and chief executive officer of the National Research Council. In 1937 and in 1939, respectively, he was awarded the Edison and the Hoover Medal, AIEE. In 1940 he was senior consultant on power, Office of Production Management, and served as its special consultant on capacity of the steel industry in 1941; in 1943, honorary president, Pan American Society; 1944, president, Phi Beta Kappa associates, member of Governor Dewey's committee on technical industrial development, and honorary member American Society of Mechanical Engineers; in 1945 chairman, executive committee of the Pilgrims; chairman, American Executive Committee of the World Power Conference; overseas representative for the United States, Institution of Electrical Engineers of Great Britain.

**Gano Dunn**

**John Mills** (A '11, F '23) director of publication since 1925 of the Bell Telephone Laboratories, Inc., New York, N. Y., retired as of April 30, 1945. Mr. Mills received the bachelor-of-arts degree from the University of Chicago in 1901, and the master-of-arts degree from the University of Nebraska in 1904. He also spent eight years at Western Reserve University, Massachusetts Institute of Technology, and Colorado College. In 1911 Mr. Mills became identified with the research group in long-distance transmission instituted by the American Telephone and Telegraph Company. His work formed a solid basis for the engineering of lines for repeater operation. After the transcontinental telephone Mr. Mills was assigned to the construction of stations and antennas for the transatlantic line. Immediately thereafter he was transferred to the engineering department of Western Electric Company working first on radio transmission and specifically on methods at a receiving station for reducing static. In World War I he trained in radio the group of Western Electric men who became the nucleus of the Signal Corps research and inspection group of the American Expeditionary Forces. Then in 1922 Mr. Mills began to work in personnel. With the incorporation of Bell Telephone Laboratories, Mr. Mills was named director of publication. In this capacity he took over some existing functions, such as information services to the associated companies and the public, the Bell System Historical Museum, and planned a magazine of information on the work of the Laboratories, the first issue of which appeared in September 1925. Another of his contributions was in the field of exhibits, and he assumed responsibility for their design and installation. Mr. Mills has served on several committees of the AIEE, and has been especially active on the publication committee of which he has been a member since 1941.

**C. E. Stephens** (M '22) vice-president, Westinghouse Electric Corporation, New York, N. Y., has retired. Mr. Stephens was born in Ferris, Texas, and attended the Ferris Institute. He joined the Westinghouse corporation in 1900 as an apprentice in the East Pittsburgh shops. Leaving the student work, he worked in the testing department and in the engineering department. After an assignment on motor insulation design and development he was made manager of the arc lighting section of the engineering department, and then was promoted to the position of illuminating engineer of the general engineering department. Subsequently he was made manager of the illuminating section of the sales department, from which position in 1917 he was transferred to the New York office as manager of the supply department. Later he was made manager of the central station division of the New York office, and in 1925 he was manager of the district, the largest within the Westinghouse district sales divisions. In 1930 he was elected commercial vice-president and two years later vice-president. He has served as vice-president of the Electrical Association of New York, vice-president of the Illuminating Engineering Society, and on the administrative board and as treasurer of the American Engineering Council Assembly. Mr. Stephens at one time served as a director of the Institute and has been active on many committees including the following: finance; code of principles of professional conduct; co-ordination of Institute activities; headquarters; executive; Popular Science award; Edison medal; production and application of light, and on the special committees on biographies and talking motion pictures; model registration law, and bust of Edison for Munich Museum.

**R. T. Henry** (A '24, F '33) formerly assistant chief electrical engineer, engineering department, Buffalo (N. Y.) Niagara and Eastern Power Corporation, has been appointed chief electrical engineer. He was born in Stronghurst, Ill. In 1908 he became associated with the General Electric Company at Lynn, Mass., subsequently serving Niagara Falls (N. Y.) Hydraulic Power and Manufacturing Company, Hooker Electrochemical Company, Niagara Falls; Edison Illuminating Company, Detroit, Mich., and the Niagara Electric Service Corporation. From 1918 until 1929 he was assistant electrical engineer with the Niagara Falls Power Company, and in the latter year became electrical engineer in charge of design, Buffalo, Niagara and Eastern Power Corporation, and was made assistant chief electrical engineer in 1942. Mr. Henry was a member of the National Electric Light Association serving on several committees, and was chairman of the electrical equipment committee of the Edison Electric Institute, 1942–43. He has been prominent in AIEE affairs acting as chairman of the Niagara Frontier Section for the year following August 1, 1929, and has served on many committees. These include the following: protective devices, for which he was chairman, 1932–34; technical program; Standards, for which he was chairman, 1940–42; planning and co-ordination; production and application of light; Standards council, ASA, and the Charles LeGeyt Fortescue Fellowship. Mr. Henry was awarded the 1933 AIEE national prize for the best paper on engineering practice.

**Edith Clarke** (A '23, M '33) engineer, central station department, General Electric Company, Schenectady, N. Y., retired July 31 after completing 26 years of service with the company. Miss Clarke was born in Howard County, Md., and received her education at Vassar College, University of Wisconsin where she studied civil engineering, and the Massachusetts Institute of Technology where she received the master-of-science degree in electrical engineering in 1919. From 1912–1915 Miss Clarke was associated with the American Telephone and Telegraph Company as computer for the research engineer, and for the next three years she was in charge of calculations in the transmission and protection engineering department. In 1919 she joined the General Electric Company as a member of the turbine engineering department. Two years later she received a leave of absence to serve as professor of physics at the Constantinople (Turkey) Women's College. In 1922 returning to the General Electric Company she went to work on technical problems dealing with the generation and transmission of power, later taking charge of engineers handling such problems as power system stability, and load distribution. She is the author or co-author of many technical papers, and wrote a book entitled "Circuit Analysis of A-C Power Systems."

**F. H. Brown** (A '38, F '45) sales engineer, Copperweld Steel Company, New York, N. Y., New England territory, has been transferred to the home office, Glassport, Pa., where he will be staff engineer in the general sales department. Before joining the Copperweld Steel Company, Mr. Brown was purchasing agent for the city of Bangor, Me. and prior to that he was engineer with the Electric Bond and Share Company, New York. **H. M. MacDougal** (A '40) electrical engineer, sales engineering department, succeeds Mr. Brown. In 1930 Mr. MacDougal was affiliated with the New York State Electric and Gas Corporation, Ithaca district, as assistant resident engineer, and in 1938 with the Copper Wire Engineering Association, Washington, D. C., as electrical engineer. In 1942 he became chief of the public utility unit, conservation division, War Production Board, Washington, D. C., and in 1943 became associated with the Copperweld Company.

**F. E. Fairman, Jr.** (M '41) formerly assistant manager, switchgear division, central station department, General Electric Company, Philadelphia, Pa., has accepted the positions of manager of the Peerless Division and a vice-president of Food Machinery Corporation, New York, N. Y. Mr. Fairman is a graduate of the United States Naval Academy, joining the General Electric Company in 1923 as a switchgear engineer at their Baltimore, Md., works. That same year he received the Coffin award for advance in air circuit-breaker design. In 1941 he was promoted to assistant manager of the switchgear division.

**M. G. Crosby** (M '41) former radio engineer, research department, RCA laboratories, Radio Corporation of America, Riverhead, N. Y., has joined the Paul Godley Company, Upper Montclair, N. J., where he will specialize in radio communication systems. Mr. Crosby graduated from the University of Wisconsin in 1927 with the bachelor-of-science degree and in 1943 received the electrical-engineering degree. He has been a research engineer for the communications division of the RCA laboratories since 1925 and in that position specialized in frequency modulation. In 1943 and 1944 Mr. Crosby served as expert technical consultant to the Secretary of War. He is the owner of many patents and the author of technical articles on frequency and phase modulation. He is a fellow of the Institute of Radio Engineers and the Radio Club of America and has served on the AIEE membership committee of the New York Section.

**P. L. Warren** (A '26, M '38) lieutenant commander, United States Naval Reserve, has returned as president and treasurer of the Royal Electric Manufacturing Company, Chicago, Ill. Commander Warren became identified with the Royal Electric company in 1936. Prior to this he had been associated with the Ohio Brass Company, also of Chicago.

**R. C. McMaster** (A '39) formerly instructor in electrical engineering, California Institute of Technology, Pasadena, has accepted an appointment to the staff of Battelle Institute, Columbus, Ohio, and has been assigned to its division of industrial physics. Doctor McMaster received the degrees of bachelor of science in electrical engineering from the Carnegie Institute of Technology and master of science and doctor of philosophy from the California Institute of Technology. In 1936 he became associated with the General Electric Company, Schenectady, N. Y., as a student engineer and in 1937 took the position of teaching assistant in electrical engineering at the California Institute of Technology. He left to become instructor in electrical engineering at the Case School of Applied Science, Cleveland, Ohio, in 1938, and subsequently returned to the California Institute of Technology as instructor in electrical engineering and supervisor of welding and X-ray research. Doctor McMaster is now serving on the AIEE electric-welding committee.

**C. A. B. Halvorson** (M '22) consulting engineer, lighting section, River Works, General Electric Company, Lynn, Mass., has retired. Mr. Halvorson joined the General Electric Company as junior test man in 1898, in 1902 became a lighting engineer, and in 1906 was named the company's first manufacturing engineer. Three years later he was appointed designing engineer of the street-lighting department and in 1930 became consulting engineer. In World War I, he designed the first floodlights used to light the Statue of Liberty and an antiaircraft searchlight for the Government and in this war has been engaged in confidential work for the Army and Navy. Mr. Halvorson is a member and past vice-president of the Illuminating Engineering Society and the Society of Motion Picture Engineers. He has served on the AIEE committee on production and application of light and is the author of several technical papers.

**R. D. Bennett** (F '35) captain, United States Naval Reserve, director of technical development, Naval Ordnance Laboratory, United States Navy Yard, Washington, D. C., has been awarded an honorary doctor of science degree from Union College. A graduate of Union College in 1921, Captain Bennett is the inventer of a device for measurement of cosmic rays and former professor of electrical measurements at the Massachusetts Institute of Technology, Boston. **H. V. Putman** (A '23, M '32) vice-president, Westinghouse Electric Corporation, Sharon, Pa., also received an honorary degree from Union College. Mr. Putman has been associated with Westinghouse corporation since 1925, and previously received from Union College, the degrees of bachelor of science in 1920, master of science in 1921, and doctor of philosophy in 1923.

**N. R. Gibson** (M '32) vice-president, Buffalo (N. Y.) Niagara and Eastern Power Corporation, has been promoted to the post of senior vice-president. Doctor Gibson has been with the company and its predecessors since 1918 when he became hydraulic engineer for the old Hydraulic Power Company, Niagara Falls, N. Y. He is chief engineer of Niagara Hudson System Companies, vice-president of Niagara Hudson Power Corporation, and president of Canadian Niagara Power Company, Ltd. In 1930 he was awarded the Elliot Cresson gold medal by the Franklin Institute of Pennsylvania for his invention of the Gibson method and apparatus for measuring the flow of liquids in closed conduits.

**E. S. Bundy** (A '14, F '33) chief electrical engineer for the Western Division companies of Buffalo, Niagara and Eastern Power has been named chief engineer and vice-president. Mr. Bundy was graduated from Cornell University in 1911 and began work shortly after that with the Niagara, Lockport and Ontario Power Company, Syracuse, N. Y., working in various capacities in the western and central divisions of the company until 1923 when he was named electrical engineer for the company in Syracuse. In 1932 he became assistant electrical engineer for Buffalo Niagara Electric Power Corporation and in 1936 was promoted to the position of chief electrical engineer. In addition to this assignment he has also been supervising the engineering for the Niagara Hudson System since 1941.

**F. R. Bacon** (A '10, M '20) president, Cutler-Hammer, Inc., Milwaukee, Wis., has been elected chairman of the board. Founder of the company, Mr. Bacon has been president from 1896 except for the years from 1924 to 1931 when he acted as chairman of the board, the position he now holds. **J. C. Wilson** (M '18) vice-president, was elected vice-president and secretary; **P. B. Harwood** (M '36, F '42) manager, engineering department, has become vice-president in charge of engineering; **Philip Ryan** (A '22, M '30) works manager, has been elected vice-president in charge of manufacturing, and **E. W. Seeger** (A '16, F '36) manager, development department, is the new vice-president in charge of development, and in addition becomes assistant secretary. All the newly elected vice-presidents have been with the company for a period of 25 years or more.

**T. H. Haines** (A '23, F '44) assistant vice-president and superintendent of transmission and distribution department, Boston (Mass.) Edison Company, has been appointed co-ordinator of management personnel, a newly established industrial-relations position within the company. During the period of Mr. Haines' work in this capacity, **E. C. Rue** (A '25, M '43) assistant superintendent, transmission and distribution department, will serve as acting superintendent. **J. F. Archibald** (M '43) assistant head of distribution operating, has accepted the promotion to head the overhead section of the transmission and distribution department, and **T. A. Pinkham, Jr.** (A '44) assistant division head, transmission and distribution department, becomes head of the underground division.

**J. S. Wise, Jr.** (A '96, M '27) president, Pennsylvania Power and Light Company, Allentown, has retired. A graduate of the University of Pennsylvania in 1898 with the bachelor-of-science degree in engineering, Mr. Wise gained early experience with the General Electric Company, Schenectady, N. Y., Atlantic City (N. J.) Electric Light Company, and the Auburn (N. Y.) Light, Heat and Power Company. In 1906 he became general manager and director of The Harwood Electric Company, Hazleton, Pa., and in 1913 acted in a similar capacity for the Lehigh Navigation Electric Company, Allentown. In 1922 he accepted the position as general manager of the Pennsylvania Power and Light Company, and in 1929 became its president.

**T. O. Kennedy** (M '18, F '39) president and general manager, Ohio Public Service Company, Cleveland, has resigned. Mr. Kennedy became associated with the public utility industry in 1907 after his graduation from the University of Missouri. In 1922 he was sent to Cleveland as vice-president and general manager of the Ohio Public Service Company, subsequently being elected president. **R. E. Burger** (F '30) president, Cities Service Power and Light Company, Jersey City, N. J., of which Ohio Public Service is a subsidiary, has been elected president and general manager to succeed Mr. Kennedy. Mr. Burger began his utility career in Ohio in 1909 and from that time until 1920 served as manager in many of the cities now served by Ohio Public Service Company.

**D. W. Atwater** (A '34) in charge of the illuminating engineering department, Westinghouse Electric Corporation, Bloomfield, N. J., will head the newly consolidated departments, resulting from a merger of the illuminating engineering department with the commercial engineering department, as manager of commercial engineering. Since joining the Westinghouse corporation in 1920 as a lamp engineer, Mr. Atwater has been identified with many pioneer movements in modern lighting. He was active in the illumination of the Philadelphia Sesquicentennial; Century of Progress Exposition in Chicago; Holland Tunnel, New York, N. Y., and the New York World's Fair.

**C. E. Brown, Jr.** (A '40) formerly vice-president, The Okonite Company, Washington, D. C., has been appointed vice-president and general sales manager to co-ordinate the activities of the executive offices in Passaic, N. J. Mr. Brown joined the Okonite sales organization in 1919, first serving as an agent with the Central Electric Company, Chicago, Ill., and in 1925 as manager of the company's power and light department in the territory around Chicago, Ill.

**G. A. Horton** (A '44) formerly project engineer, in charge of the Photometric Laboratory, United States Army Air Forces, Wright Field, Dayton, Ohio, has accepted a position as laboratory supervisor, lighting division, Westinghouse Electric Corporation, Cleveland, Ohio.

**Gerhard Mauric** (A '43) engineer since 1943 with Electrical Engineering and Manufacturing Corporation, Los Angeles, Calif., has been appointed chief engineer. Upon graduation from Technical University, Vienna, in 1928, with the degree of electrical engineer, Mr. Mauric became a test engineer, Elin Ag Weiz, Austria. In 1929 he accepted the position of service superintendent for Western Electric Company, Austria, engaged in instruction and supervision of service men for all of Central Europe except Germany. In 1940 he became associated with Lear Avia, Inc., Los Angeles.

**A. B. Cooper** (M '16, F '33) president, Ferranti Electric, Ltd., Mount Dennis, Toronto, Ontario, Canada, has been elected president of the Canadian Electrical Manufacturers' Association at its first general membership meeting in Toronto; **A. S. McCordick** (M '30) vice-president, Moloney Electric Company of Canada, Ltd., Toronto, was elected a vice-president; **L. E. Messinger** (A '30, M '44) president and managing director, Canadian Line Materials, Ltd., Toronto, has accepted the position of treasurer; and **G. W. Lawrence** (A '19) president, Sangamo Company, Ltd., Leaside, Ontario, has become a member of the executive committee.

**John Romano** (A '42) application engineer, Delta Star Electric Company, Chicago, Ill., has been appointed assistant sales manager. Mr. Romano became associated with the company in 1927 as a draftsman, and subsequently did work in sales, mainly the estimate and design of outdoor substations. **C. F. Bolles** (M '40) sales engineer, New York (N. Y.) office, has been named assistant manager and engineer of that office. Mr. Bolles joined the company in 1936 to do engineering work in connection with the sale of high-voltage switchgear and electrical equipment to utilities and industrials in the metropolitan area.

**F. W. Godsey, Jr.** (A '30, M '36) staff assistant, new products division, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been appointed manager of that division. Prior to going to Westinghouse corporation he was development engineer with the Safety Car Heating and Lighting Company, and chief electrical engineer and assistant production manager for the Sprague Electric Company, North Adams, Mass. Mr. Godsey joined the Westinghouse corporation in 1940 to serve in the division he now directs.

**C. L. Collens, 2d** (A '07, M '40) chairman, Reliance Electric and Engineering Company, Cleveland, Ohio, has been elected president of the Associated Industries of Cleveland. Mr. Collens has served on the board of directors of the American Standards Association and of the National Industrial Conference Board, and as president of the National Electrical Manufacturers' Association, and president of the Electric Power Club.

**H. B. Leidy** (A '34) assistant manager, Middle Atlantic district, manufacturing and repair department, Westinghouse Electric Corporation, Philadelphia, Pa., has been appointed manager of that district and department. Mr. Leidy studied engineering at Bucknell University before obtaining a commission in the United States Army in 1917. He joined the Westinghouse corporation in 1920, serving as field engineer, salesman, and branch manager at the Wilkes-Barre (Pa.) manufacturing and repair department, and in 1942 was made assistant manager.

**D. C. Ober** (A '16) formerly vice-president in charge of operations, Cleveland (Ohio) Electric Illuminating Company, has been elected executive vice-president of the company. He entered the employment of the company in 1912 while still a student of the Case School of Applied Science, and in 1914 took a full-time position in the electrical-engineering department. In 1917 he became assistant in charge of the department, in 1933 he was promoted to executive engineer, later was appointed manager of operations, and subsequently became vice-president.

**F. F. Fowle** (A '02, M '12) head of the firm, Frank F. Fowle and Company, Chicago, Ill., has been chosen to receive the Octave Chanute medal for 1944, awarded by the Western Society of Engineers. Mr. Fowle is known for his work as consulting engineer and author, and is a member of numerous engineering and scientific societies. The medal, established by Octave Chanute during his term as president of the Western Society of Engineers, is awarded for the best papers in civil, mechanical, and electrical engineering presented before the society.

**J. R. Beard** (F '41) senior partner, Merz and McLellan, consulting engineers, Milburn, Esher, Surrey, England, has been elected chairman of the Association of Consulting Engineers. Mr. Beard is a past president of the Institution of Electrical Engineers.

**T. R. Halman** (A '36, M '43) former relay engineer, The Detroit (Mich.) Edison Company, has been appointed supervising engineer, testing and relaying, electrical system. Mr. Halman has been associated with the company since 1922.

## OBITUARY • • • •

**Leonard J. Moore** (A '15, M '31, F '42) retired executive engineer for the Pacific Gas and Electric Company, Fresno, Calif., died June 4, 1945, in Fresno. Born April 27, 1885, in Lynnville, Iowa, Mr. Moore received the degree of bachelor of science in electrical engineering in 1908, and had the professional degree of electrical engineer conferred upon him in 1935, both being received from Iowa State College. Between the years 1908 to 1911, he was employed by the Telluride Power Company (succeeded by the Utah Power and Light Company) in Utah and Idaho as power-house operator in hydroelectric plants and later as instructor in a technical school for employees. In 1911 he entered the San Joaquin Light and Power Corporation, Fresno, to work on substation maintenance and construction, and subsequently became load dispatcher in 1912, engineering assistant to the general superintendent in 1916, in charge of design and construction in 1918, executive engineer in 1921, and was named division executive engineer, San Joaquin power division, Pacific Gas and Electric Company, Fresno, in 1938. In that year that company took over the San Joaquin Light and Power Corporation. He retired from this company in 1944. Mr. Moore served as chairman for the engineering section of the Pacific Coast Electrical Association, and was a member of the electrical-apparatus committee of the National Electric Light Association. He was a former member of the AIEE committees on protective devices and domestic and commercial applications, and was the author of numerous technical articles.

**Walton Charles Poole** (M '39) chief electrical engineer of the Sinclair Refining Company in East Chicago, Ill., died recently. Mr. Poole was born in Chelsea, Okla., in 1889, and received his education at the Willie Halsell College in Vinita and at the University of Oklahoma. In 1907 he became associated with the United States Navy as electrician in the fire control and communications section. In 1912 and for seven years thereafter he served the Vinita (Okla.) Producing and Refining Company as electrical superintendent engaged in installing the power plant, distribution lines, and general plant layout. In 1919 he went with the Sinclair Refining Company at Coffeyville, Kan., as electrical superintendent on the construction of the $5,000,000 oil refinery there. He remained in that location for four years, and in 1923 he covered East Chicago, Ind., and Chicago, Ill., as electrical engineer in charge of the design, supervision of purchases, installation and maintenance of all the electrical equipment of the company, including generating stations, substations, distribution and use in all of the refineries, pipe line, oil production and sea-going vessels of the Sinclair Consolidated Oil Corporation.

**Albert Reinhold Alliason** (A '32, M '43) professor and head of the electrical-engineering department, Wayne University, Detroit, Mich., died June 5, 1945. Professor Alliason was born May 15, 1891 in Sandwich, Ill., and received the degrees of bachelor of science in 1926 and master of science in 1927 from the University of Michigan. During World War I, 1917–19, he served as a lieutenant in the engineer corps of the United States Army Air Service, and from 1920–1926 he was instructor in automotive electrical systems at Cass High School, Detroit. In 1927 he became instructor of the department of physics and electrical engineering for the College of the City of Detroit where he remained during the evolution of the college into Wayne University, and subsequently in 1933 he was promoted to the head of the department of electrical engineering when the college of engineering was established. Professor Alliason was credited with being the inventer of the vernier radio dial, and was a member of the Engineering Society of

Detroit and of the Society for the Promotion of Engineering Education. He was also a member of the Engineers' Council for Professional Development, serving on the national committee on student selection and guidance. He was at one time on the staff of the board of directors of the AIEE Michigan Section.

**Clyde Larzelere Chatham** (A '25, M '32) assistant division superintendent, electric distribution department, Public Service Electric and Gas Company, Paterson, N. J., died suddenly on June 7, 1945, a few days before he was to take over the superintendency of the Passaic division. Born February 16, 1901 at Williamsport, Pa., Mr. Chatham received the degrees of bachelor of science in 1921 and master of science in 1922 in electrical engineering, from the Massachusetts Institute of Technology. Previous to graduation he gained early experience with the Bell Telephone Company of Pennsylvania, at Williamsport, and in the Lynn (Mass.) works of the General Electric Company. In 1921 he was employed as electrician for the New York and Pennsylvania Paper Company, Lock Haven, Pa., and in 1922 he became cadet engineer with the Public Service Electric and Gas Company, and subsequently was promoted to engineer of the Passaic division, electric distribution department. He was later made assistant division superintendent. Mr. Chatham was at one time a member and served on a subcommittee of the National Electric Light Association, and as a result of his investigations and research several technical reports were published.

**Harry Charles Frank** (M '41) research engineer, high-tension laboratories, General Cable Corporation, Bayonne, N. J., died June 9, 1945. Born February 13, 1892, in Newark, N. J., Mr. Frank received the degrees of bachelor of science from Cooper Union in 1917 and master of science from the Stevens Institute of Technology in 1932. In 1908 he was engaged as a laboratory assistant with the Weston Electrical Instrument Company, Newark, N. J., and in 1910 became associated with the New York Edison Company (N. Y.), in the maintenance of the company's primary and secondary electrical standards of measurement. In 1916 he was in the employ of the Public Service Commission for the state of New York as a junior electrical engineer, and in 1920 accepted the position as instructor of physics at the Stevens Institute of Technology, subsequently becoming assistant professor of physics in 1924. He entered the industrial field again in 1939 when he became associated with General Cable Corporation, engaged in research on high-voltage power cables in the company's research laboratory. Mr. Frank was a member of the American Physical Society, the American Physics Teachers, and the Society for the Promotion of Engineering Education.

**Adolf Alfred Julius Westman** (A '07, M '20) electrical engineer, Montreal, (Quebec, Canada) Tramways Company, died June 22, 1945. Born June 23, 1877, Mr. Westman received his education at the Northern Latin College, Stockholm, Sweden. In 1904 he entered the employ of the New York (N. Y.) Edison Company as electrical draftsman in the distribution department, and in 1907 he resigned from that company to accept a position with the General Electric Company, Schenectady, N. Y., as electrical designer. In 1910 he became associated with the electrical department of the New York, New Haven, and Hartford Railroad Company, New Haven, Conn., and three years later in 1913 he was serving as electrical designer for the J. G. White and Company, New York, N. Y. In 1914 he left that company to work in a similar capacity for the Montreal Public Service Corporation. In 1917 Mr. Westman was transferred to the Montreal Tramways Company as electrical engineer. He was a member of the Quebec Professional Engineers.

# MEMBERSHIP • • •

## Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before October 15, 1945 or December 15, 1945, if the applicant resides outside of the United States or Canada.

### To Grade of Member

Armiger, C. F., City of Baltimore, Baltimore, Md.
Bladen, A. M., Neiler, Rich & Bladen, Chicago, Ill.
Champagne, L. J., Sperry Gyroscope Co., Inc., Boston, Mass.
Chin, L. Q. H. (Re-election), Westinghouse Intl. Co., New York, N. Y.
Crow, G. L., Gen. Elec. Co., Schenectady, N. Y.
Davis, L. B. (Re-election), Chesapeake & Potomac Tel. Co., Washington, D. C.
Elliott, M. B. (Re-election), Gen. Elec. Co., Schenectady, N. Y.
Elphick, J. F., Winchester Elect. Dept., Winchester, England
Gnauck, R. E., Lt. Cmdr., U.S.N.R., Washington, D. C.
Grant, H. H., Jr., Key System, Oakland, Calif.
Hoge, R. H., Clark Cont. Co., Cleveland, Ohio
Horbach, S., Operations Branch, Army Comm. Serv., Philadelphia, Pa.
Howard, J. G. (Re-election), Koppers Co., Inc., Pittsburgh, Pa.
Ishler, K. H., Penna. Elec. Co., Erie, Pa.
Mackintosh, D. C., Gen. Elec. Co., Schenectady, N. Y.
McCulley, J. A., Wheeling Elec. Co., Wheeling, W. Va.
Morgan, J. T. (Re-election), Charleston Elec. Sup. Co., Charleston, W. Va.
Morwood, J. E. (Re-election), Brisbane City Council, Brisbane, Australia
Nin, G. L., Kellex Corp., Knoxville, Tenn.
Payman, H. S., A. B. Metal Products, Ltd., Feltham, England
Peacock, F. E., Erik Floor & Associates, Chicago, Ill.
Phelps, G. H., Westinghouse Elec. Corp., Baltimore, Md.
Roberts, C. F., Jr. (Re-election), Major, U. S. Army, Fort Bragg, N. C.
Skaglund, H. A., Lear, Inc., Hollywood, Calif.
Skrotzki, B. G. A., McGraw-Hill Pub. Co., New York, N. Y.
Twomey, R. G., Tenn. Val. Auth., Chattanooga, Tenn.
Wilson, P. J. (Re-election), Walsh-Kaiser Co., Providence, R. I.

27 to grade of Member

### To Grade of Associate

**United States and Canada**

1. North Eastern

Barton, R., Gen. Elec. Co., Lynn, Mass.
Berig, L., Boston Elev. Ry., Boston, Mass.
Craig, D. E., Gen. Elec. Co., Schenectady, N. Y.

2. Middle Eastern

Bennet, W. R., Westinghouse Elec. Corp., Lima, Ohio
Chesley, C. W., Charleston Elec. Sup. Co., Charleston, W. Va.
Clay, M. K., Semet Solvay Co., Longacre, W. Va.
Fasel, W. C., Penna. Elec. Co., Erie, Pa.
Hatch, C. B., Amer. Tel. & Tel. Co., Charleston, W. Va.
Henderson, W. D., U. S. Navy Dept., Washington, D. C.
Higgins, A. T., Lt. Cmdr., Naval Air Station, Lakehurst, N. J.
Hunn, R. J., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Hunsinger, G. O., Natl. Elec. Prod. Corp., Ambridge, Pa.
Keer, W. A., Struthers Dunn, Inc., Philadelphia, Pa.
Long, C. C., Amer. Tel. & Tel. Co., Charleston, W. Va.
Meussdorffer, R., Robbins & Myers, Inc., Springfield, Ohio
Moore, R. V., Lt. Cmdr., R.N., British Adm. Del., Washington, D. C.
Price, H. W., Jr., Bendix Radio, Towson, Md.
States, J. H., Natl. Elec. Prod. Corp., Ambridge, Pa.
Thompson, R. J., Cleve. Elec. Illumg. Co., Cleveland, Ohio
Williams, F., Firestone Tire & Rubber Co., Akron, Ohio
Zirm, R. R., U. S. Naval Res. Lab., Washington, D. C

3. New York City

Cissel, F. G., Smith, Hinchman & Grylls, New York N. Y.
Kaszychi, J., Lt. (jg), U. S. Navy, New York, N. Y.
Levine, B., Bendix Avia. Corp., Brooklyn, N. Y.
Monahan, T. I., U. S. Navy Yard, Brooklyn, N. Y.

4. Southern

Brady, G. R., Jr., Ingalls Shipbldg. Corp., Decatur, Ala.
Riley, G., Ala. Pr. Co., Birmingham, Ala.

5. Great Lakes

Brown, F. H., Pub. Serv. Co. of Northern Ill., Chicago, Ill.
dePool, N. S., Detroit Edison Co., Detroit, Mich.
Girard, J. P., Jr., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Grosser, E. H., Jr., Commonwealth Edison Co., Chicago, Ill.
Hendrickson, M. L., Commonwealth Edison Co., Chicago, Ill.
Hernandez, V. A., Student, Tri-State Col., Angola, Ind.
Howe, H. L., Pullman-Standard Car Mfg. Co., Chicago, Ill.
James, F. P., Commonwealth Edison Co., Chicago, Ill.
Loew, G. A., Allis-Chalmers Mfg. Co., West Allis, Wis.
Odlag, J., Illinois Pr. Co., Decatur, Ill.
Pordes, F., Russel Elec. Co., Chicago, Ill.
Proper, H. B., Pub. Serv. Co. of Northern Ill., Chicago, Ill.
Quist, W. G., Minneapolis-Honeywell Reg. Co., Minneapolis, Minn.
Schmidt, E. E., Cent. Ill. Pub. Serv. Co., Springfield, Ill.
Speer, F. R. (Re-election), Ind. & Mich. Elec. Co., South Bend, Ind.
Stull, K. R., Square D Co., Milwaukee, Wis.
Swikert, C. A., Hatfield Elec. Co., South Bend, Ind.
Underwood, M. R., Indianapolis Pr. & Lt. Co., Indianapolis, Ind.
Vanderheiden, V. A., Radio Station WIBA, Madison, Wis.

6. North Central

Wallis, G. F., Colo. Fuel & Iron Corp., Pueblo, Colo.

7. South West

Deal, W. R., Captain, U. S. Army, Austin, Texas
Freeman, J. L., Remington-Arms Co., Inc., Independence, Mo.
Horrigan, W. R., Allis-Chalmers Mfg. Co., Amarillo, Texas
Jones, L. W., Kansas City Pr. & Lt. Co., Kansas City, Mo.
Lewis, R. S., Okla. Gas & Elec. Co., Oklahoma City, Okla.
Mulholland, R. A., Austin Engg. Co., Austin, Texas

8. Pacific

Crouch, A. E., Dept. of Pub. Works, San Diego, Calif.
Hubbard, L. W., Jr., North Amer. Avia., Inc., Inglewood, Calif.
Kubias, F. F., Gen. Elec. Co., Los Angeles, Calif.
LaZelle, L. L., U. S. Navy Radio & Sound Lab., San Diego, Calif.
Liles, R. B., United Engg. Co., Ltd., Alameda, Calif.
Marsden, R. W., United Engg. Co., Ltd., Alameda, Calif.
Nutter, L. D., Jr., Austin Co., Pittsburg, Calif.
Spalding, R. H., Jr., U. S. Navy, San Francisco, Calif.
Teach, C. L., Lieut., U.S.N.R., San Francisco, Calif.

9. North West

Bucholz, C. S., E. I. du Pont de Nemours & Co., Inc., Richland, Wash.
Hargreaves, P. F., Puget Sound Pr. & Lt. Co., Seattle, Wash.
Weller, R. I., Guy F. Atkinson Co., Seattle, Wash.
White, D. C., Oreg. Shipbldg., Corp., Portland, Oreg.

10. Canada

Haacke, E. M., "Electrical News & Engineering," Toronto, Ont., Can.

**Elsewhere**

Banerjee, B. N., Tate Iron & Steel Co., Ltd., Tatanagar, India
Flashman, J. S., Elect. Lt., R.N.V.R., London, England
Goobich, A., U. S. Engineers Office, Oahu, T. H.
Howard, H. J., British Elec. & Allied Mfgrs. Assn., London, England
Majumdar, D., Keymer, Bagshawe & Co., Ltd., Calcutta, India
Meredith, A. E., ICI (Metals), Ltd., Birmingham, England
Rao, K. S., Praga Tools Corp., Ltd., Hyderabad, India

Total to grade of Associate

United States and Canada, 67

Elsewhere, 7

# Officers and Committees for 1945–46

## Officers

### President

WILLIAM E. WICKENDEN — Cleveland, Ohio
(*Term expires July 31, 1946*)

### Junior Past Presidents

NEVIN E. FUNK — Philadelphia, Pa.
(*Term expires July 31, 1946*)

CHARLES A. POWEL — East Pittsburgh, Pa.
(*Term expires July 31, 1947*)

### Vice-Presidents

| District | | |
|---|---|---|
| 1 | R. T. HENRY | Buffalo, N. Y. |
| 3 | J. F. FAIRMAN | New York, N. Y. |
| 5 | M. S. COOVER | Ames, Iowa |
| 7 | R. W. WARNER | Austin, Tex. |
| 9 | C. B. CARPENTER | Portland, Ore. |
| | | (*Terms expire July 31, 1946*) |
| 2 | E. S. FIELDS | Cincinnati, Ohio |
| 4 | H. B. WOLF | Charlotte, N. C. |
| 6 | L. M. ROBERTSON | Denver, Colo. |
| 8 | F. F. EVENSON | San Diego, Calif. |
| 10 | F. L. LAWTON | Montreal, Quebec |
| | | (*Terms expire July 31, 1947*) |

### Directors

K. L. HANSEN — Milwaukee, Wis.
W. B. MORTON — Philadelphia, Pa.
W. R. SMITH — Newark, N. J.
(*Terms expire July 31, 1946*)

C. M. LAFFOON — East Pittsburgh, Pa.
C. W. MIER — Dallas, Tex.
S. H. MORTENSEN — Milwaukee, Wis.
(*Terms expire July 31, 1947*)

P. L. ALGER — Schenectady, N. Y.
M. J. McHENRY — Toronto, Ontario
D. A. QUARLES — New York, N. Y.
(*Terms expire July 31, 1948*)

J. M. FLANIGEN — Atlanta, Ga.
J. R. NORTH — Jackson, Mich.
WALTER C. SMITH — San Francisco, Calif.
(*Terms expire July 31, 1949*)

### Treasurer

W. I. SLICHTER — New York, N. Y.
(*Term expires July 31, 1946*)

### Secretary

H. H. HENLINE — New York, N. Y.
(*Term expires July 31, 1946*)

### Local Honorary Secretaries

AUSTRALIA—V. J. F. Brain, Department of Public Works, Bridge Street, Sydney, N.S.W.

BRAZIL—Richard H. Bowles, Sao Paulo Tramway Light and Power Company, Sao Paulo

ENGLAND—A. P. M. Fleming, Metropolitan-Vickers Electric Company, Trafford Park, Manchester

FRANCE—A. S. Garfield, 45 Bd. Beausejour, Paris, 16E

INDIA, NORTHERN—V. F. Critchley, 11 Bahawalpur Road, Lahore, Punjab

INDIA, SOUTHERN—N. N. Iengar, The Tata Power Co. Ltd., Bombay House, Bruce Street, Fort Bombay

NEW ZEALAND—P. H. Powell, Canterbury College, Christchurch

SWEDEN—A. F. Enstrom, Ingeniorsvetenskrapsakademien, Stockholm 5

TRANSVAAL, SOUTH AFRICA—W. Elsdon-Dew, P.O. Box 4563, Johannesburg

## General Committees

### Executive

W. E. WICKENDEN, *chairman*, Case School of Applied Science, Cleveland 6, Ohio

P. L. Alger — R. T. Henry
J. F. Fairman — W. I. Slichter
N. E. Funk — W. R. Smith

### Board of Examiners

Alexander Maxwell, *chairman*, Edison Electric Institute, 420 Lexington Ave., New York, N. Y.
H. E. Farrer, *secretary*, AIEE, 33 W. 39th St., New York 18, N. Y.

P. H. Adams — A. E. Knowlton
R. H. Barclay — C. M. Laffoon
F. E. D'Humy — R. C. Roe
E. D. Doyle — M. F. Skinker
I. W. Gross — I. A. Terry
A. L. Harding — H. M. Trueblood
L. F. Hickernell — Sidney Withington

### Code of Principles of Professional Conduct

D. D. Ewing, *chairman*, Purdue University, Lafayette, Ind.

Harry Barker — Dugald C. Jackson
E. S. Fields — S. H. Mortensen
E. H. Flath — Wm. M. Piatt

### Constitution and Bylaws

Mark Eldredge, *chairman*, 2110 Spencer Road, Silver Spring, Md.

Reginald L. Jones — C. T. Sinclair
T. G. LeClair — Walter C. Smith
I. Melville Stein

### Edison Medal

*Appointed by the president for term of five years*

J. T. Barron — R. E. Doherty, *chairman* — J. V. B. Duer
(*Terms expire July 31, 1946*)

F. D. Newbury — D. C. Prince — W. E. Wickenden
(*Terms expire July 31, 1947*)

C. R. Freehafer — C. A. Powel — David Sarnoff
(*Terms expire July 31, 1948*)

O. E. Buckley — A. E. Knowlton — H. E. Strang
(*Terms expire July 31, 1949*)

C. V. Christie — Zay Jeffries — Harold Pender
(*Terms expire July 31, 1950*)

*Elected by Board of Directors from its own membership for term of two years*

P. L. Alger — M. S. Coover — S. H. Mortensen
(*Terms expire July 31, 1946*)

J. R. North — D. A. Quarles — H. B. Wolf
(*Terms expire July 31, 1947*)

*Ex officio*

W. E. Wickenden, president
W. I. Slichter, treasurer
H. H. Henline, secretary

### Finance

W. R. Smith, *chairman*, Public Service Electric & Gas Co., 80 Park Place, Newark 1, N. J.

J. F. Fairman — D. A. Quarles

### Charles LeGeyt Fortescue Fellowship

A. R. Stevenson, Jr. — H. W. Tenney
(*Terms expire July 31, 1946*)

J. M. Gaylord — R. T. Henry, *chairman*
(*Terms expire July 31, 1947*)

Joseph W. Barker — Ernst Weber
(*Terms expire July 31, 1948*)

### Lamme Medal

Robin Beach — O. B. Blackwell — C. M. Laffoon
(*Terms expire July 31, 1946*)

W. A. Del Mar — John C. Parker, *chairman* — Philip Sporn
(*Terms expire July 31, 1947*)

H. L. Hazen — V. M. Montsinger — G. A. Waters
(*Terms expire July 31, 1948*)

### Headquarters

T. F. Barton, *chairman*, General Electric Company, 570 Lexington Ave., New York 22, N. Y.

H. H. Henline — W. R. Smith

### Members-for-Life Fund

F. M. Farmer, *chairman*, 2 East End Avenue, New York 21, N. Y.

C. R. Beardsley — R. C. Muir
E. H. Colpitts — F. D. Newbury
Frank F. Fowle — W. S. Rodman
N. E. Funk — R. W. Sorensen

### Membership

L. F. Howard, *chairman*, American Tel. & Tel. Co., 195 Broadway, New York 7, N. Y.

F. S. Bacon — W. J. Lyman
Tomlinson Fort — L. C. Miller
W. C. Fowler — E. G. D. Paterson
P. H. Hughes — D. B. Perry
A. W. Janowitz — J. R. Riley
C. W. La Pierre — R. W. Warner

*District Vice-Chairmen*

Wm. F. Cotter (1) — A. M. Spaulding (6)
E. P. Yerkes (2) — E. B. Robertson (7)
Richard F. Ham (3) — Robert C. Richey (8)
W. J. Miller (4) — H. C. Glaze, Jr. (9)
E. W. Stone (5) — Thomas Ingledow (10)

*Ex officio*

Chairmen of membership committees of all Sections

### Planning and Co-ordination

J. F. Fairman, *chairman*, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.

P. L. Alger — M. D. Hooven
G. W. Bower — T. G. LeClair
W. P. Dobson — H. S. Osborne
Mark Eldredge — W. R. Smith
H. H. Henline — C. F. Wagner

### Prizes, Award of Institute

M. D. Hooven, *chairman*, Public Service Electric & Gas Co., 80 Park Place, Newark 1, N. J.

H. W. Bibber — J. J. Pilliod
F. A. Cowan — H. E. Strang
L. A. Kilgore — C. F. Wagner
J. D. Miner, Jr. — R. J. Wiseman
H. B. Wolf

### Publication

C. F. Wagner, *chairman*, Westinghouse Electric Corporation, East Pittsburgh, Pa.

M. S. Coover — John Mills
H. H. Henline — J. J. Orr
B. M. Jones — H. H. Race
G. A. Van Brunt

### Safety

L. F. Adams, *chairman*, General Electric Company, Schenectady 5, N. Y.

Robin Beach — R. L. Lloyd
C. S. Bowden — A. C. Muir
M. M. Brandon — Albrecht Naeter
Allan B. Campbell — W. T. Rogers
C. F. Dalziel — A. B. Smith
W. P. Dobson — W. R. Smith
John Grotzinger — H. W. Tenney
F. L. Kemp — E. E. Turkington
W. B. Kouwenhoven — Wesley Weinerth
H. B. Williams

## General Committees (continued)

### Sections

G. W. Bower, *chairman*, Public Service Electric & Gas Co., 80 Park Place, Newark 1, N. J.

O. C. Brill
M. S. Coover
W. E. Enns
Carl W. Evans
F. F. Evenson
H. P. Heafer
V. P. Hessler
W. R. Hough
Frederick Krug
F. L. Lawton
T. M. Linville
E. T. Mahood
A. C. Muir
R. M. Pfalzgraff
R. G. Porter
C. S. Purnell

*Ex officio*
Chairmen of Sections

### Standards

W. P. Dobson, *chairman*, Hydro-Elec. Power Commission Laboratory, 8 Strachan Ave., Toronto, Ont.
H. E. Farrer, *secretary*, AIEE, 33 W. 39th St., New York 18, N. Y.

Other members to be appointed.

*Ex officio*

Chairmen of working and co-ordinating committees of the Standards committee
Chairmen of AIEE technical committees
Chairmen of AIEE delegations on other standardizing bodies or sole representatives thereon
President, U. S. National Committee of the International Electrotechnical Commission

### Student Branches

E. W. O'Brien, *chairman*, Southern Power & Industry, 1020 Grant Building, Atlanta 3, Ga.

M. M. Cory
H. L. Davis, Jr.
A. G. Ennis
T. G. LeClair
Everett S. Lee
Walter C. Smith
E. M. Strong
R. G. Warner
C. R. Wischmeyer

*Ex officio*
Student Branch Counselors

### Research

Members to be appointed.

### Technical Program

M. D. Hooven, *chairman*, Public Service Electric & Gas Co., 80 Park Place, Newark, N. J.
C. S. Rich, *secretary*, AIEE, 33 W. 39th St., New York 18, N. Y.

O. E. Buckley
G. R. Canning
I. S. Coggeshall
F. A. Cowan
S. H. Mortensen
Frank Thornton, Jr.
C. C. Whipple
T. A. Worcester

*Ex officio*

J. F. Fairman, *chairman*, committee on planning and co-ordination
L. F. Adams, *chairman*, committee on safety
W. P. Dobson, *chairman*, Standards committee
Chairmen of all technical committees

### Transfers

L. T. Blaisdell, *chairman*, General Electric Company, 4966 Woodland Ave., Cleveland 4, Ohio

E. A. Crellin
B. D. Hull
A. E. Knowlton
K. B. McEachron
M. J. McHenry
D. E. Moat

## Special Committees

### Ordnance Advisory Committee

E. L. Moreland, *chairman*, Jackson & Moreland, Park Square Building, Boston, Mass.
(Other members to be appointed)

### Registration of Engineers

C. R. Beardsley, *chairman*, N.Y.C. Department of Commerce, 60 Broadway, Room 1404, New York 4, N. Y.

A. T. Campbell
N. E. Funk
N. B. Hinson
T. G. LeClair
K. B. McEachron
H. O. Murphy
W. H. Stueve
M. B. Wyman

## Technical Committees

### Automatic Stations

J. A. Elzi, *chairman*, Commonwealth & Southern Corporation, Jackson, Mich.

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F. F. Ambuhl
Harris Barber
G. W. Bean
W. A. Derr
J. M. Flanigen
E. E. George
I. T. Knight
G. S. Lunge
Perry Peterson
C. F. Publow
M. E. Reagan
T. A. Taylor
J. H. Vivian
E. A. Williams, Jr.
G. S. Whitlow
C. E. Winegartner

### Air Transportation

J. D. Miner, Jr., *chairman*, Aviation Engg. Dept., Westinghouse Electric Corporation, Lima, Ohio

J. W. Allen
R. S. Bair
W. L. Berry
C. J. Breitwieser
H. R. Brown
J. B. Coleman
R. W. Gemmell
R. M. Heintz
T. B. Holliday
Charles Kingsley, Jr.
John Maxian
R. A. Millermaster
J. D. Murray
J. R. North
O. F. Olsen
S. H. Orowski
M. H. Peairs
W. A. Petrasek
E. G. Ports
H. F. Rempt
F. M. Roberts
R. A. Rugge
M. L. Schmidt
Raymond A. Smith
K. R. Smythe
T. J. Tanner
A. F. Trumbull
F. H. Walker
F. O. Wisman

### Basic Sciences

J. G. Brainerd, *chairman*, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa.

R. W. Ager
Charles Concordia
Harvey L. Curtis
A. V. Eastman
L. O. Grondahl
C. R. Hanna
H. L. Hazen
N. S. Hibshman
Jesse E. Hobson
M. J. Kelly
Wm. A. Lewis
F. C. Lindvall
Ernst Weber
K. W. Miller
Brian O'Brien
G. W. Penney
H. W. Price
Walther Richter
W. J. Seeley
M. F. Skinker
James J. Smith
F. G. Tappan
J. D. Tebo
G. S. Timoshenko
R. W. Warner

### Communication

J. J. Pilliod, *chairman*, American Tel. & Tel. Company 195 Broadway, Room 1833, New York 7, N. Y.

H. A. Affel
A. L. Albert
R. B. Beetham
H. H. Beverage
H. M. Bollinger
J. D. Booth
F. B. Bramhall
J. L. Callahan
J. W. Campbell
C. B. Carpenter
John L. Clarke
I. S. Coggeshall
J. B. Coleman
F. A. Cowan
Harold Dangerfield
H. J. Dible
H. C. Dillingham
L. J. Dunnewold
Melville Eastham
H. E. Ellithorn
H. M. Engh
E. B. Fowler
D. G. Geiger
E. E. George
C. G. Grimes
S. B. Ingram
C. B. Jolliffe
I. J. Kaar
H. E. Jones
J. W. Kidder
M. L. Lehman
L. R. Mapes
R. G. McCurdy
C. W. Mier
Lee M. Moore
H. H. Nance
H. H. Newell
L. G. Pacent
J. G. Patterson
Haraden Pratt
H. I. Romnes
John B. Russell
Arthur Bessey Smith
Rothwell E. Smith
W. B. Stephenson
T. DeWitt Talmage
H. M. Turner
Mead Warren
Wm. Comings White
E. P. Yerkes
F. C. Young

### Education

H. W. Bibber, *chairman*, Union College, Schenectady 8, N. Y.

A. L. Abert
M. S. Coover
G. F. Corcoran
E. E. Dreese
W. L. Everitt
J. E. Hobson
M. C. Hughes
E. B. Kurtz
E. A. Loew
O. D. Montgomery
J. A. Northcott, Jr.
R. G. Porter
Claire W. Ricker
L. M. Robertson
H. H. Skilling
R. W. Sorensen
J. G. Tarboux
B. R. Teare, Jr.
George B. Thomas
C. E. Tucker
C. E. Tuites
E. A. Walker
R. W. Warner
A. R. Zimmer

### Domestic and Commercial Applications

M. K. Brody, *chairman*, McCall's Test Rooms, 444 Madison Ave., New York 22, N. Y.

L. F. Adams
R. U. Berry
D. K. Blake
M. M. Brandon
A. C. Bredahl
W. B. Buchanan
H. R. Cummins
Carl W. Evans
L. R. Gamble
R. R. Herrmann
C. H. Leatham
F. W. Linder
L. W. McCullough
M. J. McHenry
H. E. Metz
W. F. Ogden
H. P. Seelye
G. C. Tenney
Gordon Thompson
Wesley Weinerth

### Electric Machinery

L. A. Kilgore, *chairman*, Westinghouse Electric Corporation, East Pittsburgh, Pa.

E. H. Alexander
Sterling Beckwith
Theodore Braaten
F. S. Brown
B. M. Cain
J. F. Calvert
A. M. de Bellis
G. T. Harness
F. E. Harrell
C. B. Hathaway
J. K. Hodnette
R. A. Hopkins
W. R. Hough
E. K. Kane
F. P. Kaspar
H. H. Kerr
C. E. Kilbourne
T. C. Lloyd
R. C. Moore
T. H. Morgan
M. S. Oldacre
F. D. Phillips
C. P. Potter
L. M. Robertson
M. L. Schmidt
W. C. Sealey
H. D. Sill
H. R. Sills
B. Van Ness, Jr.
C. G. Veinott

### Electric Welding

Lemore W. Clark, *chairman*, Detroit Edison Company, 2000 Second Ave., Detroit 26, Mich.

C. A. Adams
E. M. Callender
C. M. Chute, Jr.
C. N. Clark
W. E. Crawford
J. W. Dawson
G. H. Fett
G. W. Garman
K. L. Hansen
W. F. Hess
C. E. Humble
J. Harold Lampe
C. I. MacGuffie
C. L. Pfeiffer
Sam Shiozawa
C. E. Smith
W. Spraragen
L. K. Stringham
E. H. Vedder
B. L. Wise
M. Zucker

### Electrochemistry and Electrometallurgy

J. Elmer Housley, *chairman*, Aluminum Company of America, P. O. Box 465, Alcoa, Tenn.

J. V. Alfriend, Jr.
F. T. Chesnut
L. H. Fletemeyer
J. G. Ford
W. E. Gutzwiller
J. E. Hobson
J. B. Hodtum
W. C. Kalb
W. B. Kouwenhoven
F. L. Lawton
D. H. Levy
R. M. Pfalzgraff
T. R. Rhea
F. O. Schnure
W. R. Schofield
M. F. Skinker
N. R. Stansel
E. R. Whitehead

### Electronics

W. R. G. Baker, *chairman*, Radio Dept., General Electric Company, Bridgeport, Conn.
L. C. F. Horle, *vice-chairman*, 90 West St., New York, N. Y.
W. G. Dow, *secretary*, Radio Research Laboratory, Harvard University, Cambridge, Mass.

C. T. Burke
R. S. Burnap
L. L. Call
W. R. Clark
J. H. Cox
C. J. Crowdes
A. V. Eastman
W. J. Field
William Fraser
A. P. Godsho
C. C. Herskind
S. B. Ingram
H. L. Palmer
J. H. Palmer
W. H. Pickering
D. A. Quarles
M. E. Reagan
E. T. Sherwood
Thomas Spooner
B. F. Tellkamp
J. T. Thwaites
F. N. Tompkins
H. M. Turner
D. C. Ulrey
R. C. Waldron
Wm. Comings White
C. H. Willis
H. Winograd

### Industrial Control Devices

E. U. Lassen, *chairman*, Cutler-Hammer, Inc., 315 N. 12th St., Milwaukee 1, Wis.
Other members to be appointed.

### Therapeutics, Applications of Electricity to

W. B. Kouwenhoven, *chairman*, The Johns Hopkins University, Baltimore 18, Md.

Floyd L. Call
L. B. Claussen
W. D. Coolidge
Roy Kegerreis
H. D. Moreland
H. C. Rentschler
W. R. Smith

### Industrial Power Applications

Herbert Speight, *chairman*, Westinghouse Electric Corporation, 40 Wall St., New York 5, N. Y.

E. L. Bailey
D. L. Beeman
D. E. Bivins, Jr.
Philip Bliss
G. A. Caldwell
E. L. Carlson
Lemore W. Clark
F. W. Cramer
W. H. Dickinson
D. D. Douglass
A. B. Emrick
E. S. Fields
S. F. French
J. S. Gault
John Grotzinger
S. Headman
K. W. John
C. A. Johnson
Royce E. Johnson
A. C. Muir
J. J. Orr
J. S. Parsons
L. C. Peterman
Ralph Randall
Hugh L. Smith
T. D. Thomas
E. E. Turkington
L. A. Umansky
John M. Webb
C. C. Whipple
R. T. Woodruff

### Land Transportation

W. A. Brecht, *chairman*, Transportation Engineering, Westinghouse Electric Corporation, East Pittsburgh, Pa.

J. C. Aydelott
R. Beeuwkes
L. W. Birch
H. F. Brown
D. M. Burckett
C. M. Davis
Llewellyn Evans
E. B. Fitzgerald
J. E. Gardner
H. C. Griffith
W. S. H. Hamilton
P. H. Hatch
G. L. Hoard
J. G. Inglis
Fraser Jeffrey
L. C. Josephs
Paul Lebenbaum
P. A. McGee
W. B. Morton
Timothy H. Murphy
J. A. Noertker
A. G. Oehler
R. C. Thring
F. W. Willcutt

### Light, Production and Application of

S. G. Hibben, *chairman*, The Westinghouse Lamp Division, Bloomfield, N. J.

James F. Angier
D. W. Atwater
C. L. Dows
O. W. Holden
W. C. Kalb
H. E. Mahan
Preston S. Millar
G. T. Minasian
R. C. Putnam
Harris Reinhardt
E. M. Strong
R. W. Warner
C. C. Whipple
I. A. Yost

### Marine Transportation

W. H. Reed, *chairman*, Bruce Electric Company, 196 West Houston Street, New York 14, N. Y.

E. C. Alger
R. A. Beekman
H. C. Coleman
P. J. DuMont
J. B. Feder
A. R. Gatewood
L. M. Goldsmith
H. F. Harvey, Jr.
W. R. Hight
J. E. Jones
A. Kennedy, Jr.
C. Lynn
F. R. Maxwell, Jr.
V. M. Mayer
S. N. Mead
W. B. Morton
I. H. Osborne
E. M. Rothen
C. Stansbury
E. H. Stivender
O. A. Wilde
W. N. Zippler

### Instruments and Measurements

Truman S. Gray, *chairman*, Massachusetts Institute of Technology, Cambridge 38, Mass.

P. A. Borden
H. H. Brauer
A. L. Brownlee
L. A. Bruckmyer, Jr.
C. T. Burke
D. T. Canfield
A. D. Colvin
A. B. Craig
C. L. Dawes
F. C. Doble
E. D. Doyle
W. N. Eddy
J. L. Fuller
W. N. Goodwin, Jr.
A. J. Grant
E. I. Green
I. W. Gross
C. M. Hathaway
R. D. Hickok
G. B. Hoadley
I. F. Kinnard
W. G. Knickerbocker
A. E. Knowlton
Everett S. Lee
J. T. Lusignan
D. A. Quarles
H. C. Rankin
C. W. Ricker
A. R. Rutter
F. B. Scott
F. B. Silsbee

### Power Generation

A. J. Krupy, *chairman*, Commonwealth Edison Company, 72 West Adams St., Chicago 90, Ill.

C. P. Almon, Jr.
M. H. Arndt
A. D. Caskey
C. A. Corney
R. P. Crippen
John J. Dougherty
H. A. Dryar
J. H. Foote
A. H. Frampton
Frazer W. Gay
W. D. Hardaway
H. L. Harrington
W. F. Wetmore
C. T. Hughes
Fraser Jeffrey
C. B. Kelley
C. M. Laffoon
C. W. Mayott
H. N. Muller, Jr.
W. S. Peterson
G. M. Pollard
H. B. Reynolds
M. J. Steinberg
H. D. Taylor
Robert Treat
W. R. Way

### Power Transmission and Distribution

R. J. Wiseman, *chairman*, The Okonite Company, Passaic, N. J.

Dean W. Allen
D. L. Beeman
D. K. Blake
C. D. Brown
H. W. Clark
Harold Cole
S. B. Crary
A. E. Davison
W. A. Del Mar
Robert D. Evans
J. M. Gaylord
I. W. Gross
Herman Halperin
Edwin Hansson
K. E. Hapgood
E. R. Hendrickson
J. E. Hobson
J. B. Hodtum
E. K. Huntington
H. E. Kent
A. H. Kidder
A. A. Kroneberg
W. W. Lewis
J. T. Lusignan
W. D. Maddrey
J. E. McCormack
R. B. Miller
Lee M. Moore
E. W. Oesterreich
J. S. Parsons
L. M. Robertson
H. B. Robinson
S. J. Rosch
F. E. Sanford
R. V. Sanford
E. V. Sayles
S. E. Schultz
A. E. Silver
F. V. Smith
E. C. Starr
O. W. Titus
J. J. Torok
H. M. Trueblood
C. F. Wagner
Loyd T. Williams
H. E. Wulfing

### Protective Devices

H. E. Strang, *chairman*, General Electric Company, 1 River Road, Schenectady 5, N. Y.
H. W. Collins, *vice-chairman*, Detroit Edison Company, 2000 Second Ave., Detroit 26, Mich.
H. D. Braley, *secretary*, Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York 3, N. Y.

O. E. Charlton
William Deans
H. W. Haberl
W. A. Lewis
H. J. Lingal
F. R. Longley
J. R. North
H. V. Nye
H. H. Rudd
W. J. Rudge
J. H. Vivian

## Institute Representatives

**Aeronautical Electrical Equipment Standardization**
J. R. North, Liaison Representative with NASC and SAE

**Alfred Noble Prize Committee, ASCE**
Robin Beach

**American Association for the Advancement of Science, Council**
T. H. Morgan
I. Melville Stein

**American Committee on Marking of Obstructions to Air Navigation**
J. W. Campbell
I. W. Gross

**American Coordinating Committee on Corrosion**
H. S. Phelps
E. B. King, *alternate*

**American Research Committee on Grounding**
C. T. Sinclair

**American Standards Association, Standards Council**
R. T. Henry
J. R. North
H. S. Osborne
*Alternates*
H. E. Farrer
E. B. Paxton
J. J. Pilliod

**American Standards Association, Board of Directors**
J. T. Barron

**American Year Book, Advisory Board**
H. H. Henline

**Committee of Apparatus Makers and Users, NRC**
L. F. Adams

**Charles A. Coffin Fellowship and Research Fund Committee**
W. E. Wickenden

**Consultative Committee on Engineering (Advisory to the War Manpower Commission)**
John Castlereagh Parker

**Electrical Standards Committee, ASA**
A. C. Monteith
J. R. North
J. J. Pilliod
*Alternates*
H. E. Farrer
E. L. Moreland
E. B. Paxton

**Engineering Foundation Board**
L. W. Chubb
F. M. Farmer

(*Continued on next page*)

# Geographical District Executive Committees

| | District | Chairman (Vice-President, AIEE) | Secretary (District Secretary) | Chairman, District Committee on Student Activities (1944–45) |
|---|---|---|---|---|
| 1 | North Eastern | R. T. Henry, 303 Electric Bldg., Buffalo, N. Y. | Victor Siegfried, American Steel & Wire Co., Worcester 7, Mass. | R. G. Porter, Northeastern University, Boston, Mass. |
| 2 | Middle Eastern | E. S. Fields, Cincinnati Gas & Electric Co., 4th & Main Sts., Cincinnati, Ohio | A. A. Johnson, Westinghouse Electric Corporation, East Pittsburgh, Pa. | P. X. Rice, Pennsylvania State College, State College, Pa. |
| 3 | New York City | J. F. Fairman, Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York 3, N. Y. | C. S. Purnell, Westinghouse Electric Corporation, 40 Wall St., New York 5, N. Y. | D. H. Wright, Pratt Institute, Brooklyn, N. Y. |
| 4 | Southern | H. B. Wolf, Duke Power Company, Charlotte 1, N. C. | C. B. Galphin, 2312 Greenway, Charlotte 4, N. C. | W. O. Leflell, University of Tennessee, Knoxville, Tenn. |
| 5 | Great Lakes | M. S. Coover, Iowa State College, Ames, Iowa | N. C. Pearcy, Public Utilities Engg. & Service Corp., 231 S. LaSalle St., Chicago 4, Ill. | M. M. Cory, Michigan State College, East Lansing, Mich. |
| 6 | North Central | L. M. Robertson, Public Service Co. of Colorado, Denver, Colo. | H. F. Gidlund, Public Service Co. of Colorado, Denver, Colo. | O. E. Edison, University of Nebraska, Lincoln, Nebr. |
| 7 | South West | R. W. Warner, University of Texas, Austin, Tex. | S. R. Friedsam, 3612 Bonnie Road, Austin, Tex. | M. C. Hughes, A. & M. College of Texas, College Station, Tex. |
| 8 | Pacific | F. F. Evenson, 600 E. Harbor St., P. O. Box 1710, San Diego, Calif. | Walter L. Bryant, Univ. of Calif. Div. of War Research, U. S. Navy Radio & Sound Laboratory, San Diego 52, Calif. | F. W. Maxstadt, California Institute of Technology, Pasadena, Calif. |
| 9 | North West | C. B. Carpenter, Pacific Tel. & Tel. Co., 730 S. W. Oak St., Portland 5, Oreg. | C. C. Boozier, Westinghouse Electric Corporation, 309 S. W. Sixth Ave., Portland 4, Oreg. | L. D. Harris, University of Utah, Salt Lake City, Utah |
| 10 | Canada | F. L. Lawton, Aluminum Co. of Canada Ltd., 1700 Sun Life Bldg., Montreal, Que. | D. M. Farnham, Quebec Hydro-Elec. Commission, 107 Craig St. West, Montreal, Que. | |

Note: Each District executive committee includes also the chairmen and secretaries of all Sections within the District, and the District vice-chairman of the AIEE membership committee.

## Institute Representatives (continued)

**Engineering Societies Monographs Committee**
F. M. Farmer — W. I. Slichter

**Engineering Societies Personnel Service, Inc.**
H. H. Henline

**Engineers' Council for Professional Development**
O. W. Eshbach — Everett S. Lee — E. C. Stone

**Hertz Award Committee**
M. S. Coover

**Hoover Medal Board of Award**
H. H. Barnes, Jr. — F. M. Farmer — John C. Parker

**John Fritz Medal Board of Award**
Nevin E. Funk — C. A. Powel
H. S. Osborne — David C. Prince

**Joint Conference Committee of Founder Societies and A.I.Ch.E.**
H. H. Henline — C. A. Powel — W. E. Wickenden

**Library Board, United Engineering Trustees, Inc.**
H. H. Henline — G. L. Knight
N. S. Hibshman — W. I. Slichter

**Marston Medal Board of Award**
H. B. Gear

**National Bureau of Engineering Registration, Advisory Board**
C. R. Beardsley

**National Fire Protection Association, Electrical Committee**
L. F. Adams — W. Ralph Smith, *alternate*

**National Fire Waste Council**
L. F. Adams — Wills Maclachlan

**National Research Council, Division of Engineering and Industrial Research**
Wm. B. Kouwenhoven

**Quarterly of Applied Mathematics**
J. G. Brainerd

**Radio Technical Planning Board**
H. A. Affel

**Research Procedure Committee, Engineering Foundation**
W. A. Lewis

**United Engineering Trusties, Inc.**
F. M. Farmer — C. R. Jones — Everett S. Lee

**U. S. National Commission, International Commission on Illumination**
J. W. Barker — Robin Beach — S. G. Hibben

**U. S. National Committee, International Electrotechnical Commission**
A. C. Monteith — J. R. North — J. J. Pilliod
*Alternates*
H. E. Farrer — E. L. Moreland — E. B. Paxton

**Washington Award Commission**
H. B. Gear — L. R. Mapes

**World Power Conference, Executive Committee of U. S. National Committee**
W. E. Wickenden

## General Counsel

Parker & Aaron, 55 Liberty Street, New York 5, N. Y.

# Student Branches of the Institute

| Name and Location | District | Counselor (Member of Faculty) |
|---|---|---|
| Akron, Univ. of, Akron, Ohio | 2 | |
| Alabama Polytechnic Inst., Auburn | 4 | |
| Alabama, Univ. of, University | 4 | W. J. Miller |
| Alberta, Univ. of, Edmonton, Can. | 10 | R. E. Phillips |
| Arizona, Univ. of, Tucson | 8 | J. C. Clark |
| Arkansas, Univ. of, Fayetteville | 7 | W. B. Stelzner |
| British Columbia, Univ. of, Vancouver, Can. | 10 | |
| Brooklyn, Polytechnic Inst. of, Brooklyn, N. Y. | 3 | A. B. Giordano |
| Brown University, Providence, R. I. | 1 | |
| Bucknell Univ., Lewisburg, Pa. | 2 | |
| Calif. Inst. of Tech., Pasadena | 8 | W. H. Pickering |
| Calif. Univ. of, Berkeley | 8 | P. L. Morton |
| Carnegie Inst. of Technology, Pittsburgh, Pa. | 2 | |
| Case School of Applied Science, Cleveland, Ohio | 2 | |
| Catholic Univ. of America, Washington, D. C. | 2 | |
| Cincinnati, Univ. of, Cincinnati, Ohio | 2 | |
| Clarkson College of Technology, Potsdam, N. Y. | 1 | |
| Clemson Agricultural College, Clemson, S. C. | 4 | F. T. Tingley |
| Colorado State Col. of A. & M. Arts, Fort Collins | 6 | F. B. Beatty |
| Colorado, Univ. of, Boulder | 6 | Platt Wicks |
| Columbia Univ., New York, N. Y. | 3 | W. A. LaPierre |
| Connecticut, Univ. of, Storrs | 1 | |
| Cooper Union, New York, N. Y. | 3 | E. E. Shelton |
| Cornell Univ., Ithaca, N. Y. | 1 | |
| Delaware, Univ. of, Newark, Del. | 2 | |
| Denver, Univ. of, Denver, Colo. | 6 | F. H. McClain |
| Detroit, Univ. of, Detroit, Mich. | 5 | H. O. Warner |
| Drexel Inst. of Technology, Philadelphia, Pa. | 2 | |
| Duke Univ., Durham, N. C. | 4 | Otto Meier, Jr. |
| Florida, Univ. of, Gainesville | 4 | E. F. Smith |
| George Washington Univ., Washington, D. C. | 2 | |
| Georgia School of Technology, Atlanta, Ga. | 4 | H. B. Duling |
| Harvard Univ., Cambridge, Mass. | 1 | J. P. Newton |
| Idaho, Univ. of, Moscow, Idaho | 9 | J. Hugo Johnson |
| Illinois Inst. of Technology, Chicago, Ill. | 5 | E. H. Freeman |
| Illinois, Univ. of, Urbana | 5 | E. A. Reid |
| Iowa State Col., Ames | 5 | B. S. Willis |
| Iowa, Univ. of, Iowa City | 5 | H. R. Reed |
| Johns Hopkins Univ., Baltimore, Md. | 2 | |
| Kansas State Col., Manhattan | 7 | R. G. Kloeffler |
| Kansas, Univ. of, Lawrence | 7 | G. A. Richardson |
| Kentucky, Univ. of, Lexington | 4 | Brinkley Barnett |
| Lafayette Col., Easton, Pa. | 2 | |
| Lehigh Univ., Bethlehem, Pa. | 2 | |
| Louisiana State Univ., Baton Rouge | 4 | M. B. Voorhies |
| Louisville, Univ. of, Louisville, Ky. | 4 | M. C. Northrup |
| Maine, Univ. of, Orono | 1 | |
| Manhattan Col., New York, N. Y. | 3 | R. T. Weil |
| Marquette Univ., Milwaukee, Wis. | 5 | E. W. Kane |
| Maryland, Univ. of, College Park | 2 | |
| Mass. Inst. of Technology, Cambridge 39 | 1 | |
| Michigan Col. of Mining & Tech., Houghton | 5 | G. W. Swenson |
| Michigan State Col., East Lansing | 5 | M. M. Cory |
| Michigan, Univ. of, Ann Arbor | 5 | J. S. Gault |
| Milwaukee School of Engg., Milwaukee, Wis. | 5 | E. L. Wiedner |
| Minnesota, Univ. of, Minneapolis | 5 | J. H. Kuhlmann |
| Mississippi State Col., State College | 4 | L. L. Patterson |
| Missouri School of Mines & Met., Rolla | 7 | F. H. Frame |
| Missouri, Univ. of, Columbia | 7 | M. P. Weinbach |
| Montana State Col., Bozeman | 9 | E. W. Schilling |
| Nebraska, Univ. of, Lincoln | 6 | O. E. Edison |
| Nevada, Univ. of, Reno | 8 | S. G. Palmer |
| Newark Col. of Engineering, Newark, N. J. | 3 | J. C. Peet |
| New Hampshire, Univ. of, Durham | 1 | |
| New Mexico State College, State College | 7 | H. A. Brown |
| New Mexico, Univ. of, Albuquerque | 7 | R. W. Tapy |
| New York, Col. of the City of, New York | 3 | Harry Baum |
| New York Univ., New York | 3 | P. C. Cromwell |
| North Carolina State Col., Raleigh | 4 | L. M. Keever |
| North Dakota State Agri. Col., Fargo | 5 | H. S. Rush |
| North Dakota, Univ. of, Grand Forks | 5 | C. W. Rook |
| Northeastern Univ., Boston, Mass. | 1 | |
| Northwestern Univ., Evanston, Ill. | 5 | R. Beam |
| Norwick Univ., Northfield, Vt. | 1 | |
| Notre Dame Univ. of, Notre Dame, Ind. | 5 | J. A. Northcott |
| Ohio Northern Univ., Ada | 2 | |
| Ohio State Univ., Columbus | 2 | |
| Ohio University, Athens | 2 | |
| Oklahoma A. & M. College, Stillwater | 7 | A. Naeter |
| Oklahoma, Univ. of, Norman | 7 | C. L. Farrar |
| Oregon State Col., Corvallis | 9 | A. L. Albert |
| Pennsylvania State Col., State College | 2 | |
| Pennsylvania, Univ. of, Philadelphia | 2 | |
| Pittsburgh, Univ. of, Pittsburgh, Pa. | 2 | |
| Pratt Institute, Brooklyn, N. Y. | 3 | D. H. Wright |
| Princeton Univ., Princeton, N. J. | 2 | |
| Puerto Rico, Univ. of, Mayaguez, P. R. | 3 | M. Wiewall, Jr. |
| Purdue Univ., Lafayette, Ind. | 5 | R. B. Marshall |
| Rensselaer Polytechnic Inst., Troy, N. Y. | 1 | |
| Rhode Island State Col., Kingston, R. I. | 1 | |
| Rice Institute, Houston, Texas | 7 | M. V. McEnamy |
| Rose Polytechnic Inst., Terre Haute, Ind. | 5 | C. C. Knipmeyer |
| Rutgers Univ., New Brunswick, N. J. | 3 | P. S. Creager |
| Santa Clara, Univ. of, Santa Clara, Calif. | 8 | W. J. Warren |
| South Carolina, Univ. of, Columbia | 4 | Samuel Litman |
| South Dakota State Col., Brookings | 5 | W. H. Gamble |
| South Dakota State School of Mines, Rapid City | 6 | E. E. Clark |
| Southern California, Univ. of, Los Angeles, Calif. | 8 | P. S. Biegler |
| Southern Methodist Univ., Dallas, Texas | 7 | R. L. Biesele, Jr. |
| Stanford Univ., Stanford University, Calif. | 8 | H. H. Skilling |
| Stevens Inst. of Technology, Hoboken, N. J. | 3 | W. L. Sullivan |
| Swarthmore Col., Swarthmore, Pa. | 2 | |
| Syracuse Univ., Syracuse, N. Y. | 1 | |
| Tennessee, Univ. of, Knoxville | 4 | J. G. Tarboux |
| Texas A. & M. Col., College Station | 7 | M. C. Hughes |
| Texas Tech. Col., Lubbock, Texas | 7 | W. F. Helwig |
| Texas, Univ. of, Austin | 7 | A. W. Straiton |
| Tufts College, Medford, Mass. | 1 | |
| Tulane Univ., New Orleans 15, La. | 4 | M. G. Zervigon |
| Union Col., Schenectady 5, N. Y. | 1 | |
| Utah, Univ. of, Salt Lake City | 9 | O. C. Haycock |
| Vanderbilt Univ., Nashville, Tenn. | 4 | S. R. Schealer |
| Vermont, Univ. of, Burlington | 1 | |
| Villanova Col., Villanova, Pa. | 2 | |
| Virginia Military Inst., Lexington, Va. | 4 | J. S. Jamison |
| Virginia Polytechnic Inst., Blacksburg | 4 | Claudius Lee |
| Virginia, Univ. of, Charlottesville, Va. | 4 | L. R. Quarles |
| Washington, State College of, Pullman | 9 | H. F. Lickey |
| Washington, Univ. of, Seattle | 9 | R. E. Lindblom |
| Washington Univ., St. Louis, Mo. | 7 | D. A. Fischer |
| West Virginia Univ., Morgantown | 2 | |
| Wisconsin, Univ. of, Madison | 5 | G. F. Tracy |
| Worcester Polytechnic Inst., Worcester, Mass. | 1 | |
| Wyoming, Univ. of, Laramie | 6 | R. O. Trueblood |
| Yale University, New Haven, Conn. | 1 | |
| Total Branches | 125 | |

# Local Sections of the Institute

| Name | District | When Organized | Membership Aug. 1, 1945 | Chairman | Secretary | Secretary's Address |
|---|---|---|---|---|---|---|
| Akron | 2 | Aug. 12, '20 | 105 | M. B. Rankin | F. J. Ilse | 795 West Market St., Akron 3, Ohio |
| Alabama | 4 | May 22, '29 | 37 | F. C. Weiss | Robert S. Morrison | Westinghouse Electric Corp., 1406 Comer Bldg., Birmingham 3, Ala. |
| Arizona | 8 | Mar. 22, '41 | 60 | Charles A. Rollins | E. A. Gissel | Central Arizona Light & Power Co., Phoenix, Ariz. |
| Beaumont | 7 | June 27, '45 | 61 | Harold McIntosh | N. C. Spencer | 2555 North St., Beaumont, Texas |
| Boston | 1 | Feb. 13, '03 | 673 | F. S. Bacon, Jr. | R. E. Muehlig | Westinghouse Electric Corp., 235 Old Colony Ave., Boston, Mass. |
| Central Indiana | 5 | Jan. 12, '12 | 147 | S. C. Leibing | E. G. Hinshaw | Indiana Bell Telephone Co., 240 N. Meridian St., Indianapolis, Ind. |
| Chicago | 5 | 1893 | 959 | J. F. Calvert | L. R. Janes | Public Service Co. of Northern Ill., 72 West Adams St., Chicago 3, Ill. |
| Cincinnati | 2 | June 30, '20 | 161 | F. W. Willey | Paul H. Goodell | 4817 Section Avenue, Cincinnati 12, Ohio |
| Cleveland | 2 | Sept. 27, '07 | 423 | V. A. Diggs | R. W. Loehr | Westinghouse Electric Corp., 1216 West 58th St., Cleveland 1, Ohio |
| Columbus | 2 | Mar. 17, '22 | 90 | N. J. Greene | O. E. Holzer | 397 Acton Rd., Columbus 2, Ohio |
| Connecticut | 1 | Apr. 16, '21 | 384 | Vincent J. Hayes | Elmer G. Horton | Westinghouse Electric Corp., P. O. Box 1817, New Haven 8, Conn. |
| Dayton | 2 | June 9, '43 | 243 | F. S. Himebrook | W. A. Dynes | 312 Lonsdale Ave., Dayton 9, Ohio |
| Denver | 6 | May 18, '15 | 209 | Louis A. Goalby | Leroy R. Patterson | Public Service Co. of Colorado, Denver, Colo. |
| East Tennessee | 4 | Sept. 2, '36 | 288 | C. P. Almon, Jr. | S. E. Lyons | Tennessee Valley Authority, Power Bldg., Chattanooga, Tenn. |
| Erie | 2 | Jan. 11, '18 | 73 | Harold S. Ogden | Wilbur C. Brown | General Electric Co., East Lake Road, Erie, Pa. |
| Flordia | 4 | Jan. 28, '31 | 125 | P. J. Carlin | C. H. Summers | Florida Power & Light Co., Miami, Fla. |
| Fort Wayne | 5 | Aug. 14, '08 | 107 | E. G. Downie | L. L. Ray | General Electric Co., 1635 Broadway, Fort Wayne 2, Ind. |
| Georgia | 4 | Jan. 14, '04 | 145 | Carl W. Evans | Robert O. Loomis | Georgia Power Co., Atlanta 1, Ga. |
| Houston | 7 | Aug. 7, '28 | 143 | S. C. Commander | H. Lee Miller | Houston Lighting & Power Co., P. O. Box 1700, Houston 1, Texas |
| Illinois Valley | 5 | June 30, '45 | 47 | F. E. Dace | R. P. Johnson | 2511 W. Forrest Hill Ave., Peoria 5, Ill. |
| Iowa | 5 | June 29, '29 | 85 | John A. Green | Wallace L. Cassell | Iowa State College, Ames, Iowa |
| Ithaca | 1 | Oct. 15, '02 | 72 | N. L. Platt | W. H. Erickson | School of Elec. Engg., Cornell University, Ithaca, N. Y. |
| Kansas City | 7 | Apr. 14, '16 | 149 | A. F. Hartung | J. E. Murray | J. E. Murray & Co., 1805 Grand Ave., Kansas City 8, Mo. |
| Lehigh Valley | 2 | Apr. 16, '21 | 188 | L. Z. Ludorf | A. L. Price | 173 South Church St., Hazleton, Pa. |
| Los Angeles | 8 | May 19, '08 | 718 | Earl S. Condon | H. D. Strong | General Electric Co., P. O. Box 2830 Terminal Annex, Los Angeles 54, Calif. |
| Louisville | 4 | Oct. 15, '26 | 75 | S. H. Gates | L. W. Anderson | 647 Starks Bldg., Louisville 2, Ky. |
| Lynn | 1 | Aug. 22, '11 | 210 | C. B. Fontaine, Jr. | Mark A. Princi | 19 Clifton Ave., Marblehead, Mass. |
| Madison | 5 | Jan. 8, '09 | 81 | J. A. Roller | Carl C. Crane | 3810 Council Crest, Madison 5, Wis. |
| Mansfield | 2 | Mar. 6, '39 | 63 | C. L. Lisle | H. E. Edwards | Westinghouse Electric Corp., Mansfield, Ohio |
| Maryland | 2 | Dec. 16, '04 | 417 | J. L. Hildebrandt | Edwin Hansson | Penn. Water & Power Co., 1409 Lexington Bldg., Baltimore 1, Md. |
| Memphis | 4 | May 22, '30 | 94 | J. A. Crisman | W. R. Moyers, Jr. | 3480 Macon Rd., Memphis, Tenn. |
| Mexico | 3 | June 29, '22 | 181 | F. A. Nava | Oscar R. Enriquez | Ave. Chapultepec 281-6, Mexico, D. F. Mexico |
| Michigan | 5 | Jan. 13, '11 | 436 | L. W. Clark | G. M. Chute | General Electric Co., 700 Antoinette St., Detroit 2, Mich. |
| Milwaukee | 5 | Feb. 11, '10 | 408 | G. W. Clothier | E. T. Sherwood | Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis. |
| Minnestoa | 5 | Apr. 7, '02 | 133 | Leroy A. Griffith | John H. Merriman | Northern States Power Co., 15 South St., Minneapolis 2, Minn. |
| Montana | 9 | June 24, '31 | 71 | F. E. Gardiner | E. W. Williams | 715 W. Galena St., Butte, Montana |
| Montreal | 10 | Apr. 16, '43 | 237 | John J. Dougherty | Harold H. Remine | Quebec Hydro Elec. Commission, Montreal, Que., Canada |
| Muscle Shoals | 4 | Feb. 18, '38 | 19 | W. E. Lindemann | Ernest L. Bishop | 76 F St., Village 1, Wilson Dam, Ala. |
| Nebraska | 6 | Jan. 21, '25 | 48 | M. L. Burgess | I. M. Ellestad | Northwestern Bell Tel. Co., Omaha, Neb. |
| New Mexico–West Texas | 7 | Mar. 7, '40 | 57 | Robert C. Dickson | John F. Armstrong | 3219 Altura Blvd., El Paso, Texas |
| New Orleans | 4 | Dec. 8, '33 | 159 | Wm. Stone Leake | S. L. Kennedy | Louisiana Power & Light Co., Metairie, La. |
| New York | 3 | Dec. 10, '19 | 3,949 | J. L. Callahan | W. J. Barrett | New Jersey Bell Telephone Co., 540 Broad St., Newark 2, N. J. |
| Niagara Frontier | 1 | Feb. 10, '25 | 198 | J. M. Geiger | John D. Hershey | General Electric Co., 1 West Genessee St., Buffalo 2, N. Y. |
| North Carolina | 4 | Mar. 21, '29 | 137 | Otto Meier Jr. | J. O. Kimrey | Duke Power Co., 112 North Mangum St., Durham, N. C. |
| North Texas | 7 | May 18, '28 | 199 | R. W. Roessler | H. K. Doyle | Dallas Power & Light Co., Dallas, Texas |
| Oklahoma City | 7 | Feb. 16, '22 | 109 | W. A. Kitchen | H. E. Brashear | Southwestern Bell Tel. Co., Oklahoma City, Okla. |
| Philadelphia | 2 | Feb. 18, '03 | 925 | C. T. Pearce | W. R. Clark | Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa. |
| Pittsburgh | 2 | Oct. 13, '02 | 693 | C. M. Skooglund | J. B. Hodtum | Allis-Chalmers Mfg. Co., N. S. Station, Pittsburgh 12, Pa. |
| Pittsfield | 1 | Mar. 25, '04 | 201 | M. E. Scoville | J. C. Russ | Power Transformer Engg. Dept., General Electric Co., Pittsfield, Mass. |
| Portland | 9 | May 18, '09 | 228 | O. A. Demuth | W. Morgan Allen | Pacific Tel. & Tel. Co., 730 S. W. Oak St., Portland, Oreg. |
| Providence | 1 | Mar. 12, '20 | 104 | Donald E. Walch | George E. Andrews | Narragansett Electric Co., Melrose St., Providence, R. I. |
| Rochester | 1 | Oct. 9, '14 | 133 | Ernest B. Kempster | George R. Town | Stromberg-Carlson Co., 100 Carlson Rd., Rochester 3, N. Y. |
| St. Louis | 7 | Jan. 14, '03 | 346 | Harry B. Seybt | R. C. Horn | 1820 Telephone Bldg., 1010 Pine St., St. Louis 1, Mo. |
| San Diego | 8 | Jan. 18, '39 | 102 | R. R. Richey | G. E. Jenner | 861 Sixth St., San Diego 12, Calif. |
| San Francisco | 8 | Dec. 23, '04 | 776 | D. I. Anzini | H. E. Becker | Westinghouse Electric Corp., 1 Montgomery St., San Francisco 4, Calif. |
| Schenectady | 1 | Jan. 26, '03 | 654 | P. H. Light | B. H. Caldwell | Motor & Gen. Engg. Div., General Electric Co., Schenectady 5, N. Y |
| Seattle | 9 | Jan. 19, '04 | 303 | E. B. Hansen | George M. Palo | 1707 Bigelow Ave. North, Seattle 9, Wash. |
| Sharon | 2 | Dec. 11, '25 | 149 | A. D. Forbes | C. W. Miller | 840 Mayfield Rd., Sharpsville, Pa. |
| South Bend | 5 | Feb. 26, '41 | 70 | C. D. Highleyman | John C. Learman | 1245 North Meade St., South Bend, Ind. |
| South Carolina | 4 | Mar. 2, '40 | 56 | F. T. Tingley | J. L. Weeks | South Carolina Elec. & Gas Co., Columbia, S. C. |
| South Texas | 7 | May 23, '30 | 56 | N. Bernard Gussett | Robert M. Eichner | General Electric Co., 1014 Transit Tower, San Antonio, Texas |
| Spokane | 9 | Feb. 14, '13 | 106 | J. F. Gogins | R. R. Ries | 1528 West Augusta, Spokane 12, Wash. |
| Springfield | 1 | June 29, '22 | 60 | Byron N. Durfee | Fred G. Webber | 9 Federal Court, Springfield, Mass. |
| Syracuse | 1 | Aug. 12, '20 | 149 | C. E. H. Von Sothen | L. J. Audlin | Central N. Y. Power Corp., 300 Erie Blvd. West, Syracuse 2, N. Y. |
| Toledo | 2 | June 3, '07 | 67 | F. C. Helwig | Walter M. Campbell | 2145 Central Grove Ave., Toledo, Ohio |
| Toronto | 10 | Sept. 30, '03 | 400 | A. H. Frampton | J. F. Moore | Dunlop Wire & Rubber Goods, 870 Queen St., E., Toronto, Ont., Canada |
| Tulsa | 7 | Oct. 1, '37 | 81 | P. E. Gentry | L. F. Rylander | Public Service Co. of Oklahoma, 600 So. Main St., Tulsa, Okla. |
| Urbana | 5 | Nov. 25, '02 | 38 | E. A. Reid | C. A. Keener | 308 Elec. Engg. Lab., University of Illinois, Urbana, Ill. |
| Utah | 9 | Mar. 9, '17 | 77 | L. Dale Harris | John A. McDonald | General Electric Co., P. O. Box 779, Salt Lake City, Utah |
| Vancouver | 10 | Aug 22, '11 | 109 | J. D. Fraser | G. K. Haspel | 1992 41st Ave., West, Vancouver, B. C., Canada |
| Virginia | 4 | May 19, '22 | 136 | J. A. Rawls | C. H. Smoke | 1523 Holland Ave., Norfolk 5, Va. |
| Washington | 2 | Apr. 9, '03 | 726 | E. T. Walker | L. H. Cleary | 1022 20th St. N. W., Washington 6, D. C. |
| West Virginia | 2 | Apr. 9, '40 | 50 | W. E. Vellines, Jr. | R. F. Norwood | 1400 Bridge Road, Charleston 3, West Virginia |
| Wichita | 7 | Sept. 16, '37 | 86 | H. Kenneth Hentzen | Hugh E. Hartman | Kansas Gas & Electric Co., 201 N. Market St., Wichita 1, Kans. |
| Worcester | 1 | Feb. 18, '20 | 59 | A. L. Duna | G. W. Bibber | Heald Machine Co., New Bond St., Worcester 6, Mass. |
| Total Sections | 75 | | 19,913 | | | |

**Local Subsections**

| Name | Chairman | Secretary | Secretary's Address |
|---|---|---|---|
| Arrowhead (Minnesota Section) | H. Carpenter | R. H. Holmes | Minnesota Power & Light Co., 30 W. Superior St., Duluth 2, Minn. |
| Charleston (South Carolina) | D. H. Davis | M. G. Toole | P. O. Box 42, Navy Yard, Charleston, S. C. |
| Great Falls (Montana Section) | | D. A. Johnson | Mountain States Tel. & Tel. Co., 401 First Ave. N., Great Falls, Mont. |
| Hamilton (Toronto Section) | J. M. Somerville | W. J. Porter | Canadian Westinghouse Co., Hamilton, Ont., Canada. |
| Lake Charles (New Orleans Section) | A. D. Hargroder | G. V. Cooper | Cities Service Refining Corp., Tutwiler Refinery, Lake Charles, La. |
| Niagara Falls (Niagara Frontier Section) | G. A. Zehr | C. R. Staker | 203 79 St., Niagara Falls, N. Y. |
| Ottawa (Montreal Section) | B. G. Ballard | J. H. Simpson | National Research Council, Ottawa, Ont., Canada |
| Panhandle (North Texas Section) | J. G. Ausman | D. H. Hickey | Capitol Hotel, Amarillo, Texas |
| Rock River Valley (Madison Section) | B. T. Anderson | R. E. Schuette | Barber-Colman Co., Rockford, Ill. |
| Sacramento (San Francisco) | W. E. Camp | E. A. McGinty | Pacific Gas & Electric Co., 1314 29 St., Sacramento 16, Calif. |
| Wilmington (Philadelphia Section) | R. G. Rudrow | Henry Evans | Delaware Power & Light Co., 600 Market St., Wilmington, Del. |
| Zanesville (Columbus Section) | J. G. Tankovich | A. J. Baker | Ohio Power Co., Zanesville, Ohio |

# OF CURRENT INTEREST

## Foundation to Develop Scientific Research

A National Research Foundation established by Congress for the purpose of developing scientific research, supporting financially basic research in nonprofit organizations, encouraging scientific talent in American youth by offering scholarships and fellowships, and promoting long-range research on military matters is recommended by Doctor Vannevar Bush, director of the Office of Scientific Research and Development in a report to the White House, prepared at the request of the late President Roosevelt. Urging a new impetus to scientific research in the United States, Doctor Bush stated that research cannot be left solely to private industry though private sources should continue to carry their share of the financial burden. The 184-page report entitled, "Science, The Endless Frontier," lists five divisions of the Foundation—medical research, natural sciences, national defense, scientific personnel and education, and publications and scientific collaboration.

Referring to the deficit in trained scientific personnel in the United States, Doctor Bush suggests a program to provide 24,000 undergraduate scholarships and 900 graduate fellowships at an annual cost to the Government of approximately $30,000,000. These beneficiaries would constitute a reserve, subject to call into government service, for scientific or technical work in time of war or other emergency. He claimed that the armed services should comb their records for men who, prior to or during the war, gave evidence of talent for science, and make prompt arrangements, consistent with current discharge plans, for ordering those who remain in uniform as soon as militarily possible to duty at institutions here and overseas where they can continue their scientific education.

Basic principles which must underlie the program of Government support for scientific research and education if such support is to be effective and if it is to avoid "impairing the very things we seek to foster" are enumerated as follows:

1. Whatever the extent of support may be, there must be stability of funds over a period of years so that long-range programs may be undertaken.

2. The agency to administer such funds should be composed of citizens selected only on the basis of their interest in and capacity to promote the work of the agency. They should be persons of broad interest in and understanding of the peculiarities of scientific research and education.

3. The agency should promote research through contracts of grants to organizations outside the Federal Government. It should not operate any laboratories of its own.

4. Support of basic research in the public and private colleges, universities, and research institutes must leave the internal control of policy, personnel, and the method and scope of the research to the institutions themselves.

5. While assuring complete independence and freedom for the nature, scope, and methodology of research carried on in the institutions receiving public funds, and while retaining discretion in the allocation of funds among such institutions, the Foundation proposed herein must be responsible to the President and the Congress. Only through such responsibility can we maintain the proper relationship between science and other aspects of a democratic system. The usual controls of audits, reports, budgeting and the like, should, of course, apply to the administrative and fiscal operations of the Foundation, subject, however, to such adjustments in procedure as are necessary to meet the special requirements of research.

The report, prepared under the inspirational words of President Roosevelt—"New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war we can create a fuller and more fruitful employment and a fuller and more fruitful life," suggests legislation now declaring that early action is imperative if the United States is to meet the challenge of science and utilize to the full the potentialities of science. In the opinion of Doctor Bush the future of the United States depends upon the wisdom with which science is applied to the problems of the future.

## Radio Communication for Trains

Radio equipment for use on trains, and between trains and wayside stations will be tested on the western lines of the Illinois Central Railroad between Freeport, Ill., and Waterloo, Ia., a 162-mile district chosen for the variety of operating conditions it offers, including prairie country, bluff regions, cities, river crossings, one tunnel, and curved and straight-away track. Electronic principles developed for the Armed Forces and used on planes, tanks and in ships will be utilized.

One type to be tested, space radio, is kindred to radiobroadcasting as it is heard in American homes. It will be used primarily for talking back and forth between the engine and the caboose on a freight train. Space radio operates on the high-frequency channels which were assigned recently for train use by the Federal Communications Commission. Static and noise interference common to standard broadcasting are largely absent on these high frequencies. The equipment as developed today is a simple arrangement, consisting of only a small transmitter-receiver, a remote control box with handphone, a loud-speaker and antenna on each engine and caboose. No dependence on outside electrical devices is involved for engineer-and-conductor conversation.

The second type to be tried is carrier, or induction, radio. This equipment is not radio in the ordinary sense, for it follows wayside wires and its messages are neither beamed nor broadcast. The standard wire system already along the right-of-way is used for carrier radio without interference to the present telephone and telegraph systems. The radio messages jump the space between the wires and the radio units in the train by induction. This provides continuous communication between the operator in the wayside station and the train crew in the engine cab and the caboose.

## World Educational Body Formed

Dedicated to the proposition that the "free and unrestricted education of the peoples of the world, and the free and unrestricted exchange among them of ideas and knowledge are essential to the advancement of human welfare and to the preservation of security and peace," the Educational and Cultural Organization of the United Nations is to be established at the invitation of the British Government following a United Nations' conference scheduled for November 1, 1945 in London. Adopted in its present form by 20 nations which have been represented at meetings of the Allied Ministers of Education in England for the last two years, the charter pledges its support in helping to preserve security and peace. The new organization will promote international interchange in the fields of science, education, the arts, and the social sciences.

The purposes are clearly defined in Article 1. It reads as follows:

(*a*). To develop and maintain mutual understanding and appreciation of the life and culture, the arts, the humanities and the sciences of the peoples of the world as a basis for effective international organization and world peace.

(*b*). To co-operate in extending and in making available to all peoples for the service of common human needs the world's full body of knowledge and culture, and in assuring its contribution to the economic stability, political security, and general well-being of the peoples of the world.

## Radar Secret Revealed

No more hush! hush! on radar, a war baby which has come of age. The uses of radar—radio detection and range—in war and in peace were revealed on August 14, 1945 both in Washington and in London. The story of this device which goes back many years has been avidly awaited since it helped the British air squadrons beat off the Germans in 1940; in 1942 when the German submarine threatened the British in their island kingdom with starvation, and more recently because of its major role in the Pacific zone of fighting.

Though radar sets vary in size depending on whether they are installed on the ground, in planes or in ships, the principle is the same—the transmitting of pulses or electromagnetic waves which hit something—an area on the ground, a plane, or a ship—and bounce back into the radar receiver forming images on a screen-like device called the "scope." These pulses travel at the speed of light, namely, 186,000 miles, a second and the range is indicated by the marked circle on the "scope" in which the target image comes to rest. The direction of the target is determined by directional antennas.

Some detailed information released by the Army on the equipment and operation of radar will be published in a forthcoming issue of *Electrical Engineering*.

## General Motors Research Center Planned

Citing modern science as the real source of economic progress, Alfred P. Sloan, Jr. chairman of General Motors Corporation, New York, N. Y., recently announced the establishment of the General Motors Technical Center, which will meet tomorrow's needs for the corporation's research, advanced engineering, and styling and process development sections of its general staff activities. In making this announcement at a "More Jobs Through Research" luncheon in the Waldorf-Astoria Hotel, New York, before a representative group of scientists, educators, editors, engineers and industrialists, Mr. Sloan further declared that this new center represents long-considered plans of General Motors Corporation to expand, at the right time and on a broad scale, its peacetime research, and engineering activities.

The various buildings comprising the General Motors Technical Center will be grouped around a central esplanade within which will be a seven-acre lake which in itself fills a useful purpose in the operations of the Center. The Center will be erected on property one and one-half miles long and about half a mile wide covering approximately 350 acres, just outside of Detroit, Mich.

C. E. Wilson, president of the corporation, emphasized the fact that the new Technical Center would be purely a technical fact-finding and experimental development activity. However, by a close liaison between the Technical Center and the manufacturing divisions, executives of the divisions who have the responsibility for product development and processing can make decisions affecting their activities with greater assurance and with less loss of time.

According to Charles F. Kettering, vice president and director of research of the corporation, facilities are only a part of the story of this technical center. The more important factor had not been overlooked, namely, the men to use these new facilities—the men who can make ideas grow into material things. Mr. Kettering also said:

> General Motors has found through more than 30 years of practical experience that it cannot offer to the public many new and better things through the process of wishing. For this reason, each of its many divisions has its own product research and engineering departments. These are supplemented by a central research laboratory, advanced engineering section, styling section and process development section. In addition to these central facilities we have proving grounds at Milford, Mich., Pheonix, Ariz., and Miami, Fla. Rounding out this development background is the General Motors Institute at Flint, Mich., whose function is to train certain future General Motors employees in the use of their hands and minds.

## "Unit" Power Plants Designed for Europe

Small, easily transportable power plants which can be erected in a few days to generate electric current sufficient for the needs of a city of 10,000, are being shipped to Europe to speed the return of bombed-out regions to normal industrial production, according to William E. Knox, vice president of the Westinghouse Electric International Company. Each "unitized" plant embraces the primary essentials of a modern power station—generator, steam turbine, boiler, switchgear, fuel burning equipment, piping and insulation, instruments and other parts. More than 100,000 kw of electrical energy are represented in the unit plants now in actual operation or under construction. The units are of two sizes, one with a capacity of 2,000 kw, the other half as large.

The idea of a compact power-producing unit first was conceived by Mr. Knox for use in China. The Chinese needed a quick means of generating electrical power for war-production facilities which had been forced back from the coast and deep into the interior by the advancing Japanese troops. Working in conjunction with a firm of New York engineering consultants, Westinghouse designers fulfilled the demand for equipment that would operate on locally abundant low-grade coal. Other models have been built to burn lignite, oil, wood, and even peat. While the first plants were intended for permanent erection at the ultimate site, the rapid pace of the mechanized conflict upset the engineers' timetable and called for a machine that could be put together in a minimum of time. The result was a "semi-portable design" which fulfilled the purpose, and, in addition, could be set up right on the field.

Despite the diverse climates in which these plants will be used, engineers had to allow for only two variables in the design: type and grade of fuels available; and what engineers call "ambient temperature"—the air temperature at the site of the plant.

The original intent was to relieve purchasers of equipment selection and to enable them to buy from a single source.

## Culture—Aim of Proposed Curriculum

In a 267-page volume, entitled "General Education in a Free Society," a committee of Harvard University, appointed by President Conant in 1943, recommends greater emphasis on general education at all levels of instruction rather than the special education, such as vocational and trade subjects in high schools and special areas in college. General education and specialism need not be placed in competition, the report states, but it deplores the condition whereby a student receives an excellent training in chemistry, music, botany or the fine arts under an elective plan but with his general education largely neglected. Therefore, the committee recommends that a minimum of 50 per cent of a student's time be devoted to a study of general education in high school. A "core" curriculum is suggested to be built around English, science, mathematics and the social sciences. Developing a common core for all students, in the schools, it is reasoned, would help to produce more intelligent citizens for ". . . . a sound society." Specific courses are suggested, designed to achieve the aims of general education and to give the students an insight into the nature of the scientific enterprise. The aim is culture for all. Doctor Paul H. Buck, dean of the faculty of arts and sciences, headed the committee of 12 who unanimously approved the findings of the two-year study.

A new program for Yale University, New Haven, Conn., resembling these proposals has been accepted.

## General Electric Electronics Training Course

A new industrial-electronics talking slide-film training course which offers a practical understanding of industrial electronics, has been announced by the General Electric Company, Schenectady, N. Y. The course consists of 12 talking slide-films (35-mm film strips and 16-inch, $33^1/_3$-rpm records) each approximately 30 minutes in length; 25 copies each of 12-lecture review booklets keyed to the slidefilms; an instructor's manual covering the presentation of all 12 lectures; and, sturdily constructed carrying case designed to accommodate the complete course. The price of the course is $100.

Commenting on the course, L. A. Umansky (M '27), assistant manager of the company's industrial engineering divisions, said that the need for a course of this kind has been sharply felt for some time. It was his belief that an explanation of the elementary facts of electronics in a simple form, readily understood by practical men, destroys the fear of the unknown and encourages them to use this new tool as freely as they used other and older electrical tools. Also, the course pointed out the "how" and "why" of electronics in industrial life; where the use of electronics would be merely a fad of a misapplication. Only in this way did he believe electronics would find its legitimate place.

## Advocates Curtailing of German Industry

Conquered Germany's electrical equipment industry, still grossly expanded despite 40 per cent destruction by Allied bombs, must be trimmed to normal peacetime production levels, in the opinion of Charles A. Powel, newly appointed chief of the electrical and radio branch of the Allied Control Commission. Mr. Powel, past president AIEE has taken leave of absence from his position of headquarters engineering manager for the Westinghouse Electric Corporation, East Pittsburgh, Pa. Mr. Powel has first-hand knowledge of the expansion of Germany's electrical industry in pre-war years.

Speaking recently before the Pittsburgh Chamber of Commerce Mr. Powel said that his first task under the Allied Control Commission will be to make a survey to determine just how greatly this expansion overshot the nation's normal needs. Then a recommendation will be made to the commission as a basis for permissible future activity of the industry. He believed that somewhere between the two extremes of making Germany a completely agrarian nation, as advocated by some, and allowing it any and all industries on the basis that they are essential to European economy, as advocated by others, there must lie a middle road. This middle road would permit the Germans a satisfactory balance between agriculture and industry and give them a decent standard of living without allowing them to establish a new war potential.

Mr. Powel reiterated his belief in the merits of a plan previously suggested by him jointly with the presidents of four other major engineering societies—civil, mining, mechanical, and chemical. (*EE, Nov '44, p 393*)

# Stratosphere Planes for Television and Frequency-Modulation Broadcasting

Airplane operation in the stratosphere as a new system of nationwide television and frequency-modulation broadcasting was announced as a joint development of Westinghouse Electric Corporation, East Pittsburgh, Pa., and The Glenn L. Martin Company, Baltimore, Md., at a luncheon in the Waldorf-Astoria Hotel, New York, N. Y., August 9, 1945. The Federal Communications Commission has been informed of the plan which specifies a low-powered ground transmitter to send television and frequency broadcasts to a specially designed high-altitude plane circling slowly overhead. The plane would be equipped with receivers and transmitters for rebroadcasting these programs back to the earth. As now conceived a chain of planes similar to the *B*-29, each cruising over a fixed area and spanning the continent, would transmit simultaneously five frequency-modulation programs and four television shows to listeners on the ground 30,000 feet below. It was asserted that this relay system would enable 14 airplanes to cover 78 per cent of the country's population and would eliminate the need for many hundreds of ground stations.

C. E. Nobles, a young radar engineer from Texas, affiliated with Westinghouse Corporation, is credited with being the originator of the Stratovision system. He explained the radio features of the new system at the luncheon. In operation a program from a frequency-modulation or television studio would be beamed upward from a ground transmitter to the plane circling overhead. The plane would relay the signal back to ground over a 422-mile area and at the same time relay the program to the plane circling in the next area. Mr. Nobles said that an advantage of the stratosphere station was that the power needed to impress a satisfactory signal on a receiver decreased with an increase in the transmitter's height. His estimate of cost for the first experimental plane was $500,000. On the matter of cost, Walter Evans, vice-president of the Westinghouse corporation, in charge of all radio activities, added that providing comparable service by ground installation would require approximately 100 costly relay towers and hundreds of transmitters; or a coaxial cable network estimated to cost $100,000,000.

W. K. Ebel, vice-president in charge of engineering for the Martin company, went into detail on weather conditions, and said that at a six-mile altitude storms except thunderheads are below. He stated that if the country were covered with aircraft operating at all times at 30,000 feet meteorological data would be available so that we would be able to forecast weather conditions even more accurately than at present, and we could concentrate aircraft as they are needed near storm areas. Claiming that one of the unusual features of the Stratovision system was the type of plane design—a huge heavy-load plane to fly only fast enough to remain safely aloft at very high altitudes, he said that "for once we are not trying to go anywhere in a hurry, but instead want to go nowhere slowly."

**Figure 1. All-metal low-wing monoplane powered with two 1,450-horsepower engines**


**Figure 2. Plane-to-plane connections form a nationwide network**

## INDUSTRY • • • • •

**Announce Stand on Federal Power Projects.** One hundred and sixty-seven of the nation's electric light and power companies, representing a large part of the business-managed electric industry, in a joint statement on July 18, 1945, made known their position on proposed river developments by the United States Government. These developments, providing for the creation of the Missouri Valley Authority and other projects similar to Tennessee Valley Authority, as well as the completion of several already in operation, entail an estimated initial expenditure in excess of $3,850,000,000. Among the points made is one—Government may properly regulate business, but should not operate business.

### Seminar at Stevens an Aid to Industry and Management

The series of seminar meetings started in May, 1945 for industrial executives by the War Industries Training School of Stevens Institute of Technology, Hoboken, N. J., has resulted in an exchange of ideas which has affected major problems in industrial management and planning, it was revealed by Robert H. Baker, director of the school, at the seventh and final session of the series on July 10. Twelve men prominent in industry, among them plant managers, general managers, and

industrial relations directors, attended the course which became known as the "Executives Club." Members of the class said that the informal discussions under the direction of a trained industrial psychologist had been invaluable as an aid to solving many of the problems that management currently faces.

The War Industries Training School was started in January 1941, under the engineering, science, management war training program of the United States Office of Education. Since that time it has had more than 4,800 course enrollments.

**For Extensive Use of High Frequency.** A new building is now under construction at the Cambridge, Ohio, plastics-division plant of the Continental Can Company, and new types of automatic compression- and injection-molding equipment, making extensive use of high frequency, will be installed. This division was recently awarded the Army-Navy "E."

# PATENTS • • • • • • •

**To Protect Patents.** Under date of July 31, 1945, the New York Times states that United States State Department officials are seeking the adoption of some form of international agreement which would recognize American patent rights by Russia on a royalty basis. This would serve as a protection for patents of the United States often involved in development contract deals with Russian Government agencies in the system inaugurated in 1931.

**Erratum.** In an item on standards for drafting practices (*EE, May '45, p 202*) it was stated that the War Department had outlined the scope of the work to include civil, mechanical, electrical, aeronautical, and marine engineering. . . . The work is a joint venture of the War Department and the Navy Department and is conducted under the direction of the Joint Army-Navy Committee on Specifications.

# OTHER SOCIETIES •

**Committee Becomes Society.** The American-Soviet Science Society is the new name of the Science Committee, National Council of American-Soviet Friendship, Inc., New York, N. Y. All members of the latter have been invited to membership in the society. It was recommended that scientists and technologists be eligible for membership in the new society. Under the auspices of this society 300 scientists attended a reception, August 21, at Columbia University, New York, N. Y., to honor Doctor Irving Langmuir, General Electric Company, Schenectady, N. Y., and five other members of the American delegation of 16 that attended the recent scientific congress in Moscow.

## Technical Council Formed in Kansas City

Seventeen professional and technical societies of the Kansas City, Mo., area joined forces in establishing the Technical Societies Council for unified action in matters pertaining to the development of scientific endeavors. Some of the principal objectives include support for the establishment of better technical and scientific libraries in this region; encouragement for the initiation of educational courses of a technical and scientific nature in the schools of this area and coordination of the vocational-guidance activities of the constituent organizations; cooperation with civic, educational and government agencies in matters requiring professional assistance.

At the organization dinner-meeting held in Kansas City on July 9, 1945, Doctor W. M. Hoehn, member of the American Chemical Society and laboratory director of George A. Breon and Company was elected chairman. C. M. Lytle (M '42) assistant superintendent and supervisor, engineer and estimating, overhead system department, Kansas City Power and Light Company, was elected to the office of vice-chairman and Charles Briggs, member of the American Society of Mechanical Engineers, with the Burns and McDonnell Engineering Company to that of secretary-treasurer.

Headquarters of the newly formed Council will be in the offices of the Midwest Research Institute, Kansas City. Sarah C Lechtman, a member of the Institute's staff will be manager of publications and will issue a monthly publication devoted exclusively to the interests of the new Technical Council.

**New Society Formed.** The Society of Industrial Designers has been formed with temporary offices at 55 West 42d Street, New York, N. Y. The society will assume the tasks and responsibilities of a professional association. A code of professional practice is in preparation. Information, advice and assistance will be available to people and institutions engaged in teaching industrial design or engaged in public education in this field. According to the announcement every industrial designer in good standing in the United States will be eligible for membership in this society.

**New Utilities Association.** Formation of an industry-wide association of electric light and power companies with headquarters in Washington, D. C., was recently announced.

Among the aims of the association are the development of co-operation between governmental departments and agencies dealing with them and with the supply of electric power, and the presentation of facts concerning public benefits resulting from the operation of tax-paying electric utility companies as distinguished from Government ownership and operation. The organization, not yet permanently named, plans to conduct a broad program to demonstrate the contribution of the industry toward a balanced national economy.

# HONORS • • • • • •

## Accomplishments in Field of Aeronautics Cited

Doctor W. F. Durand, chairman of the division of engineering and industry of the National Research Council, Washington, has won the American Society of Mechanical Engineers Medal, the society's highest honor, for his work in aerodynamic science.

The Holley Medal of the society will go to Doctor S. A. Moss, General Electric Company engineer, West Lynn, Mass., for his many contributions to the development of centrifugal compressors, particularly to the application of turbo-superchargers to internal combustion engines in aeronautics.

The Worcester Reed Warner Medal will be awarded to Doctor J. M. Juran, assistant to the administrator of the Foreign Economics Administration, Washington, D. C., for his contribution to the problem of quality control in mass production, and for various other writings.

W. J. King, research engineer with the fuels division of Battelle Memorial Institute, Columbus, Ohio, is the winner of the Melville Prize Medal for his paper, "The Unwritten Laws of Engineering."

B. E. Del Mar, supercharging engineer with the Douglas Aircraft Company, Santa Monica, Calif., will receive the Junior Award for his paper, "Presentation of Centrifugal Compressor Performance in Terms of Nondimensional Relationships."

Honors and awards will be made at the society's meeting in New York, N. Y., in November 1945.

**Wins Annual Report Contest.** The Puget Sound Power and Light Company, Seattle, Wash., has won the 1944 award for the best annual report. The company won the prize in 1943 also. The purpose of the award, which is a bronze plaque, is to encourage the clarification of annual reports for the average reader. The winning report consisted of a 50-page bound booklet with a two-color cover, and a text replete with photographs.

**Radios as Prizes for "GI's."** Fifty postwar Bendix radio-phonograph combinations are being awarded as prizes in a war bond letter-writing contest for "GI's" in the European theater, Leonard C. Truesdell, general sales manager of radio and television, Bendix Radio division, recently announced. Certificates for postwar delivery of the combinations through distributor and dealer channels have been turned over to *Stars and Stripes*, official Army overseas newspaper, for awarding to those writing prize-winning letters on the subject, "My Savings and Postwar Plans." The contest is open to military personnel in Europe who have taken out a new war-bond allotment or have purchased a bond since May 1, 1945. The thousands of letters already received indicate that servicemen have thought about their postwar future.

# LETTERS TO THE EDITOR

**INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.**

## Determination of the Individual Resistances of a Delta Mesh by Measurements Taken at the Junctions

*To the Editor:*

Testing and analysis of a-c equipment and machinery often require the resistance of the individual delta-connected windings. In some cases it is either impossible or inconvenient to isolate the windings for direct measurement. This paper offers a method by which the individual resistances may be calculated from resistance measurements taken between the junctions of the windings.

The resistance between the three combinations of pairs of terminals or junctions of three delta-connected windings may be measured by means of a Kelvin bridge or a Wheatstone bridge depending upon the magnitude of the winding resistances. The resistances thus measured will be the resistance of one winding in parallel with the other two windings in series. From these three measurements, three independent equations may be set up involving three unknown quantities.

Let

$R_a$ = the resistance of winding *a*
$R_b$ = the resistance of winding *b*
$R_c$ = the resistance of winding *c*
$R_{AB}$ = the measured resistance between terminals *A* and *B*
$R_{BC}$ = the measured resistance between terminals *B* and *C*
$R_{CA}$ = the measured resistance between terminals *C* and *A*

Then, by parallel circuits

$$R_{AB}=\frac{R_c(R_a+R_b)}{R_c+(R_a+R_b)} \tag{1}$$

$$R_{BC}=\frac{R_a(R_b+R_c)}{R_a+(R_b+R_c)} \tag{2}$$

$$R_{CA}=\frac{R_b(R_c+R_a)}{R_b+(R_c+R_a)} \tag{3}$$

These three independent equations may be solved for $R_a$, $R_b$, and $R_c$ in terms of $R_{AB}$, $R_{BC}$, and $R_{CA}$. An inspection of these equations will show them to be nonlinear and their mathematical solution necessarily will be somewhat involved. This tedious mathematical solution can be avoided by making use of the delta-wye and the wye-delta transformations.

The delta mesh, $R_aR_bR_c$ can be replaced by the equivalent wye mesh, $R_a'R_b'R_c'$. Then

$$R_{AB}=R_a'+R_b' \tag{4}$$

$$R_{BC}=R_b'+R_c' \tag{5}$$

$$R_{CA}=R_c'+R_a' \tag{6}$$

If one solves equations 4, 5, and 6 for $R_a'$, $R_b'$, and $R_c'$,

$$R_a'=\frac{R_{AB}-R_{BC}+R_{CA}}{2} \tag{7}$$

$$R_b'=\frac{R_{BC}-R_{CA}+R_{AB}}{2} \tag{8}$$

$$R_c'=\frac{R_{CA}-R_{AB}+R_{BC}}{2} \tag{9}$$

Transforming from the wye mesh to the equivalent delta mesh gives

$$R_a=\frac{R_a'R_b'+R_a'R_c'+R_b'R_c'}{R_a'} \tag{10}$$

$$R_b=\frac{R_a'R_b'+R_a'R_c'+R_b'R_c'}{R_b'} \tag{11}$$

$$R_c=\frac{R_a'R_b'+R_a'R_c'+R_b'R_c'}{R_c'} \tag{12}$$

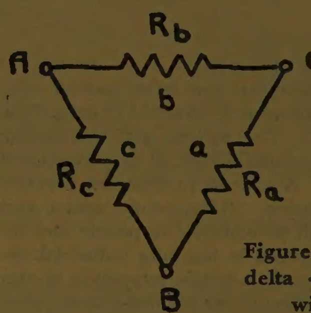


Figure 1. Three delta-connected windings

Substituting the values of $R_a'$, $R_b'$, and $R_c'$ from equations 7, 8, and 9 in equations 10, 11, and 12 gives

$$R_a=\frac{\left(\frac{R_{AB}-R_{BC}+R_{CA}}{2}\right)\left(\frac{R_{BC}-R_{CA}+R_{AB}}{2}\right)+\left(\frac{R_{AB}-R_{BC}+R_{CA}}{2}\right)\left(\frac{R_{CA}-R_{AB}+R_{BC}}{2}\right)+\left(\frac{R_{BC}-R_{CA}+R_{AB}}{2}\right)\left(\frac{R_{CA}-R_{AB}+R_{BC}}{2}\right)}{\left(\frac{R_{AB}-R_{BC}+R_{CA}}{2}\right)}$$

$$=\frac{-R_{AB}^2-R_{BC}^2-R_{CA}^2+2R_{AB}R_{BC}+2R_{AB}R_{CA}+2R_{BC}R_{CA}}{2R_{AB}-2R_{BC}+2R_{CA}} \tag{13}$$

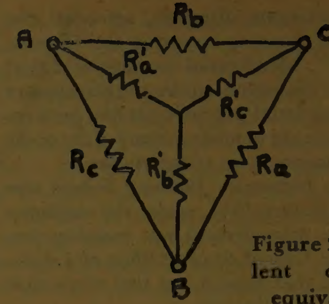


Figure 2. Equivalent delta and equivalent wye

Similarly

$$R_b=\frac{-R_{AB}^2-R_{BC}^2-R_{CA}^2+2R_{AB}R_{BC}+2R_{AB}R_{CA}+2R_{BC}R_{CA}}{2R_{BC}-2R_{CA}+2R_{AB}} \tag{14}$$

$$R_c=\frac{-R_{AB}^2-R_{BC}^2-R_{CA}^2+2R_{AB}R_{BC}+2R_{AB}R_{CA}+2R_{BC}R_{CA}}{2R_{CA}-2R_{AB}+2R_{BC}} \tag{15}$$

It will be noted that the numerators of equations 13, 14, and 15 are the same thereby reducing the arithmetical calculations after the measured values have been substituted.

LEE J. PURNELL (A '41)

(Associate professor and head of the electrical-engineering department, Howard University, Washington, D.C.)

## The Engineering Degree

*To the Editor:*

The letter by C. W. Comstock in the June 1945 issue of *Electrical Engineering* expressed opinions on the value of college degrees which coincide with those developed by 38 years in a large, highly technical organization. During ten years of this period I was associated with a large plant school when we were changing from simple manual to very complicated mechanical operations. We had unusual opportunities for research, experiment and practical application in all phases of vocational aptitude testing and training. We found it possible to determine even on 15-year old boys without previous experience or knowledge, whether individuals possessed inherent or potential faculties that fitted them for complicated electrical work. When this system was thoroughly established and had proved to be more than 90 per cent accurate, we discovered that approximately four out of five electrical engineering graduates were not natural born electrical experts. These men failed on simple tests easily mastered by 15-year old potential electricians.

Therefore, as a substitute for college degrees, we might have a system of scientific vocational aptitude testing to be based not on memory, but on a student's ability to demonstrate his powers of reasoning and practical application. An experience in Signal Corps training offers some illumination on this subject. One day a laboratory instructor bragged that his class of 20 signal men were able, after 16 weeks of training, to wire and clear trouble on a one-tube radio circuit. These men had been selected for radio training on the basis of Army classification tests. It was suggested that the instructor try an experiment in vocational psychology by drawing the one-tube circuit upside down or

the blackboard and asking just one question. "What case of trouble do you find on this circuit?" While difficult to believe, 19 out of these 20 men were very certain they found a wiring error in the circuit simply because they could not read it drawn upside down. In other words, only one man in 20 could reason about the circuit and this is a characteristic failure noted in too many electrical engineering graduates.

From an employer's point of view, a certificate based on accurate, practical application tests and guaranteeing potential or actual job proficiencies, would be much more satisfactory than the present academic degrees. Would be pleased to co-operate with anyone interested in this important subject.

FREEMAN HURD (M '43)

(Director, American Education Foundation, Inc., Chicago, Ill.)

## Bactericidal Lamps

*To the Editor:*

Because of current activity by lighting-fixture manufacturers in preparing for the ultraviolet-radiation market, it would be proper for our engineers to exercise leadership in the dissemination of information to the public regarding the potential dangers to living tissue, in the use of bactericidal lamps emitting 2537 angstroms wavelength energy.

It is quite understandable that electric-maintenance men may clean or relamp such fixtures without killing the circuit. The writer's own experience has been that five seconds radiation at two feet will give sore eyes within eight hours. We do not want an energy source of such undeveloped potentialities as the bactericidal lamp, to gain ill repute because of unguided use by the public. It therefore behooves the technical man to safeguard the public perhaps through the organization of a clearing house for information by a recognized society, for the purpose of assisting the manufacturer and the retailer in the proper presentation of this energy source to the public.

E. J. CONTIER (A '45)

Plant electrician, Monroe Calculating Machine Company, Orange, N. J.

## NEW BOOKS • • • •

**The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in these columns should be addressed to the publisher of the book in question.**

**An Introduction to Electronics.** By Ralph G. Hudson. The Macmillan Company, New York, N. Y., 1945. 97 pages, illustrated, $5^1/_2$ by $8^1/_4$ inches, $3.

Explains the science of electronics by acquainting the layman with some of the outstanding new concepts of the physical world together with the implications of their probable effect upon his manner of living. This exposition emphasizes how electrons perform and why. Aside from the astronomical figures and exceedingly small numbers that pervade the literature of electronics, the book contains practically no mathematics and presupposes no previous study of physics or chemistry. It describes the major uses of electronic tubes and phototubes, the construction of electronic devices and their working principles and paints a vivid picture of "radar"—what it has accomplished in these war years and what its unlimited possibilities portend for tomorrow.

**The Simple Calculation of Electrical Transients.** By G. W. Carter. Cambridge: At the University Press. The Macmillan Company, New York, N. Y., 1945. 120 pages, $5^1/_4$ by $7^3/_4$ inches, $1.75.

An elementary treatment of transient problems in linear electrical circuits, by Heaviside's operational method. Based upon a course of lectures given to engineers of the British Thomson-Houston Company, Limited, the book has been written with a bias toward the physical or engineering side. The ground covered is limited to the behavior of linear circuits with lumped elements. As little previous knowledge as possible has been assumed, but some knowledge which must be taken for granted has been summarized in the last four Appendices. The final chapter consists of worked-out examples, which illustrate the book's principal themes.

**Introduction to Practical Radio.** By D. J. Tucker. The Macmillan Company, New York, N. Y., 1945. 322 pages, illustrated, $5^3/_4$ by $8^3/_4$ inches, cloth, $3.

Text is confined to initial principles and basic fundamentals of radio. Necessary mathematics is included, and numerous specific examples of the practical application of principles to actual radio construction and operation are given. Provides a reference work for practicing radio engineers and technicians as well as a complete manual for beginners. The chapters on elementary electricity, Ohm's Law, resistance circuits, direct-current power and magnetism might serve as a valuable refresher course for more advanced students. Such valuable additions as a list of symbols and their meaning, a mathematical and an electrical glossary and an appendix of logarithmic and trigonometric tables are included.

**Transmission Lines Antennas and Wave Guides.** By R. W. P. King, H. R. Mimno, and A. H. Wing. McGraw-Hill Book Company, New York 18, N. Y., 1945. 347 pages, $5^1/_2$ by $8^1/_2$ inches, cloth, $3.50.

This book is an outgrowth of a special wartime pre-radar training course given in the Graduate School of Engineering, Harvard University, Cambridge, Mass. Transmission lines are presented exclusively from the high-frequency point of view; antennas from the electromagnetic theory; and wave guides are presented from the point of view of generalized transmission circuits. The section on wave propagation is brief and is intended primarily for students with a general knowledge of physics who have had no previous opportunity to study the basic principles of radio transmission.

**Engineering Preview,** an introduction to engineering including the necessary review of science and mathematics. By L. E. Grinter and others. The Macmillan Company, New York, 1945. 581 pages, illustrated, $9^1/_2$ by 6 inches, cloth, $4.50 (ESL.)

Designed for high-school seniors or college freshmen, this textbook treats the background science of engineering—mathematics, chemistry, and physics—technical drawing and some of the basic engineering applications of physics. The object is to present in an organized way the background material for later study of any specialized field of engineering and thus enable the reader to determine whether engineering is his field.

(The) **New Plastics.** By H. R. Simonds and M. H. Bigelow, assisted by J. V. Sherman. D. Van Nostrand Company, New York, N. Y., 1945. 320 pages. $8^3/_4$ by $5^1/_2$ inches, cloth, $4.50. (ESL.)

This book presents the available information on all important plastic materials developed since 1940. Separate chapters are devoted to the new fibers, new adhesives, new laminating materials, new applications of wood and paper, new forms and coatings. New and improved processes and applications for established plastics are covered, and the trend of the plastics industry is demonstrated as indicated by summarized statistical and technical information.

**Dynamic Meteorology.** By J. Holmboe, G. E. Forsythe and W. Gustin. John Wiley and Sons, New York, N. Y., Chapman and Hall, London, England, 1945. 378 pages, $8^1/_2$ by $5^1/_2$ inches, cloth, $4.50. (ESL.)

Intended as a basic introduction to theoretical meteorology, this text starts from the fundamental principles of physics, and develops the tools of thermodynamics and hydrodynamics needed for the understanding of atmospheric motion. Only material which is considered indispensable for the practical meteorologist and weather forecaster has been included. A general knowledge of physics and calculus is assumed.

**Treatise on the Theory of Bessel Functions,** 2d ed. By G. N. Watson. The Macmillan Company, New York, N. Y., The University Press, Cambridge, England, 1945, 804 pages, $10^1/_4$ by $7^1/_4$ inches, cloth, $15.00. (ESL.)

The mathematical aspects of Bessel functions are discussed with two main objects: the development of applications of the fundamental theory of functions of complex variables, and the compilation of a collection of results which would be of value to the increasing number of mathematicians and physicists who encounter Bessel functions in their investigations. An extensive bibliography is included.

**Industrial Organization and Management.** By L. L. Bethel, F. S. Atwater, G. H. E. Smith and H. A. Stackman, Jr. McGraw-Hill Book Company, New York, N. Y., and

London, England, 1945. 798 pages, 9 by $5^3/_4$ inches, cloth, $4.50. (ESL.)

Management as a field of specialization within itself, rather than as an adjunct to the study of engineering or business, is the subject of this basic text. It prepares the student for advanced work in methods, cost, industrial relations, budgeting, production control, marketing, and office management.

**Chemistry of Coal Utilization.** Prepared by Committee on Chemical Utilization of Coal, Division of Chemistry and Chemical Technology, National Research Council. John Wiley and Sons, New York, N. Y., Chapman and Hall, London, England, 1945. 1868 pages, 9 by 6 inches, cloth, $20.00 (2 Vols.). (ESL.)

Prepared by a staff of 35 contributors, this two-volume treatise constitutes a comprehensive and critical review of the voluminous but scattered literature on the scientific and practical aspects of coal utilization.

**Air News Yearbook,** Vol. 2. Duell, Sloan and Pearce, New York, N. Y., 1944. 296 pages, 9 by 12 inches, cloth, $4.75. (ESL.)

Extensive chapters on the development and operation of the air forces of the principal world powers are illustrated by some 400 photographs. Individual descriptive material is provided for all planes shown, and plane types are arranged according to the countries of their origin.

**Fundamentals of Thermodynamics.** By A. S. Adams and G. D. Hilding. Harper and Brothers, New York and London, 1945. 289 pages, $9^1/_2$ by 6 inches, cloth, $3.75. (ESL.)

The object of the authors is to give the beginning student an understanding of the fundamentals of thermodynamics adequate for further related study in mechanical engineering, physics and chemistry.

**Elementary Statistics.** By H. Levy and E. E. Preidel. Ronald Press Company, New York, 1945. 184 pages, $7^3/_4$ by 5 inches, cloth, $2.25. (ESL.)

Presents the principles of statistics briefly and simply, without requiring more mathematics than elementary algebra. It is based on courses given to students of mathematics, physics, and engineering at the Imperial College of Science, London, England.

**Coming Age of Rocket Power.** By G. E. Pendray. Harper and Brothers, New York and London, 1945. 244 pages, illustrated, $8^3/_4$ by $5^1/_4$ inches, cloth, $3.50. (ESL.)

The evolution of the rocket principle, from its discovery ages ago to such modern developments as the bazooka and the rocket plane.

**Report of the Urban Planning Conferences at Evergreen House, 1943.** Johns Hopkins Press, Baltimore, Md., 1944. 245 pages, illustrated, $9^1/_2$ by 6 inches, $2.75. (ESL.)

Presents results of a series of six conferences held under the auspices of Johns Hopkins University and participated in by many experts. The subjects discussed were the basic directives in urban planning, transportation; housing; health; recreation, and welfare.

## PAMPHLETS • • • •

**The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.**

**The Distribution of Thunderstorms and the Frequency of Lightning Flashes.** National Research Council of Canada, Ottawa, Ont., Canada. A review by R. Ruedy, Research Plans and Publications Section. Second edition, revised and enlarged. April 1945, 70 pages, $1.

**The Government's Wartime Research and Development, 1940–1944.** Part 11. Findings and Recommendations. July 1945. Report from the Subcommittee on War Mobilization to the Senate Committee on Military Affairs. By H. M. Kilgore, 74 pages.

**American Standards** (Price List of American Standards, American Safety Standards, American War Standards, and Alphabetical Index to American Standards). American Standards Association, New York 17, N. Y. 24 pages.

**Wartime Technological Developments.** Subcommittee on War Mobilization of the Committee on Military Affairs United States Senate. United States Bureau of Labor Statistics. 418 pages, 50 cents.

**Ohio's Mineral Resources.** III Salt (In Two Parts). By S. P. Hildreth, and W. R. Harris and E. J. Corell. Engineering Experiment Station, Ohio State University, Columbus, Ohio, July 1945. 19 pages.

**Science of Measurement.** Book 1–Book 8. A study course in tool inspection and the instruments that make for precision. Continental Machines, Inc., Minneapolis 4, Minn.

**Test Specifications Automatic Electric Storage Water Heaters.** Report of a joint committee of the Edison Electric Institute and National Electrical Manufacturers Association, New York, N. Y., 10 pages.

**A Survey of Technical Institutes** by Leo F. Smith (*Technical Education News*), McGraw-Hill Book Company, New York, N.Y., 4 pages.

**Facts in Figures About Atlanta.** Industrial Bureau, Atlanta Chamber of Commerce Atlanta, Ga., 40 pages.

**Rotameter Nomograph for Steam.** Fischer and Porter Company, Hatboro, Pa. (Chart on rotameter size for steam measurement).

**Radar.** (Official history of the new science with technical descriptions and glossary of Radar terms.) June 1945. British Information Services, New York, N. Y. 30 pages.

**A New Era in Flow Rate Measurement** (third revised edition). Fischer and Porter Company, Hatboro, Pa., 32 pages.

**The Decimal Point and the Slide Rule** (including some time-saving short-cuts for electrical engineers and technicians). By W. P. Miller, 5 pages.

**The National Association of Public Relations Counsel, Inc.** Its origin; its purpose; its work. International Building, Rockefeller Center, New York 20, N. Y.

**Aircraft Accessories For 400 Cycle Motor Operation.** By R. G. Holt. Pesco Products Company, Cleveland 6, Ohio, 10 pages.

**Books, Publications and Patents,** 1929–1944. Battelle Memorial Institute, Columbus, Ohio, 72 pages.

**Contractors Guide.** War and Navy Departments. (An aid in the settlement of terminated war contracts), 60 pages, free.

**Directory of Products and Engineering Literature.** Allis-Chalmers Manufacturing Company, Milwaukee, Wis., 32 pages.

**First Time in History! The Duplex Speaker.** Altec Lansing Corporation, Hollywood 28, Calif., 12 pages.

**How to Do Business with RFC.** Reconstruction Finance Corporation, Washington, D. C. 32 pages.

**Industrial Electronic Tube Manual.** General Electric Company, Schenectady, N. Y., 412 pages, $2.

**Instrument Manufacturing and Service Facilities.** Nilsson Electrical Laboratory, Inc., New York 13, N. Y., 20 pages.

**Introduction to Electronics.** By Walther Richter. Allis-Chalmers Manufacturing Company, Milwaukee, Wis., 19 pages.

**NEMA Standards for Electric Water Heaters.** Publication No. 45-104. New York, N. Y., eight pages, 25 cents.

**New Designations of Screens for Cathode-Ray Photography.** Allen B. Du Mont Laboratories, Inc., Passaic, N. J.

**OPA Reports to Congress.** By Chester Bowles to the Banking and Currency Committees. March 1945, 104 pages.

**Rotating-Blade Air-Break Switch.** (Type TW), Pacific Electric Manufacturing Corporation, San Francisco 24, Calif., 16 pages.

**Standards Review** (Period Review of the British Standards Institution). The London Press Exchange Ltd., 1945, No. 1, 2 shillings.

**The Ignitron Tube and How It Is Used.** General Electric Company, Schenectady, N. Y., 23 pages.

**We Had to Have Rubber.** The Rubber Manufacturers Association. New York 22, N. Y., 64 pages.

**9-Inch South Bend Precision Lathes.** South Bend (Ind.) Lathe Works, 35 pages.

**Dillon Dynamometer.** W. C. Dillon and Company, Chicago 44, Ill., 19 pages.

**Television As a Career.** General Electric Company, Schenectady, N. Y., 4 pages.

**Theory of the Rotameter.** Fischer and Porter Company, Hatboro, Pa., 23 pages.